

**FARM HOUSEHOLD LAND USE DECISIONS IN KIGEZI
HIGHLANDS, SW UGANDA**

By

Bamwerinde Mwetonde Wilson

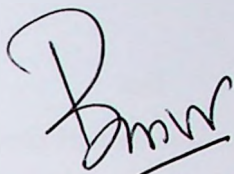
**Bachelor of Science in Forestry,
Master of Science in Environment and Natural Resources**

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**Faculty of Forestry and Nature Conservation
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April, 2006**

DECLARATION

I Bamwerinde, M. Wilson do hereby declare that this thesis is my original work and has never been submitted to Makerere University or any other institution of higher learning for a degree.



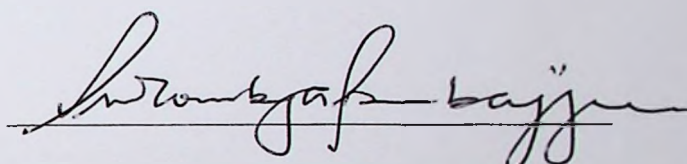
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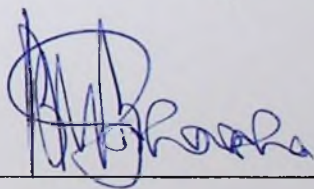


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Signed

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18th April 2006

Date

DEDICATION

TO GOD THE FATHER, SON AND THE HOLY GHOST

and

To the memory of my mother, Freda Bamukweshu. To my father John Tingirabigambo.

To my wife Florence and the children, Abraham Mwetonde, Hannah Kibukaire and
Barnabas Niwaha.

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Abstract

This study investigated the determinants of plot abandonment (unintentional fallows) and long fallows (intentional fallows) in order to propose policy interventions that lead to optimal and sustainable management of both cultivated and uncultivated land use systems in Kigezi highlands. Plot abandonment and long fallows are lands that lie idle for a considerable number of years rendering them economically undesirable. If unchecked, the two could eventually threaten the food security and retard the economic growth of small-scale farmers and the nation at large. Both descriptive and econometric techniques were used to analyze and discern factors that influence farmers' decision to subject land to different land uses.

The analysis has shown that long fallows and abandonment land use types are distinct, common and account for over 25% of the total area surveyed. Both household and plot related factors significantly determined abandonment and long fallow decisions. Household factors such as age, and post primary education positively influenced farmers' decision to abandon plots. Therefore, more fallows and abandoned terraces were common with older farmers compared to younger ones. However, farm size and household type had no significant influence on abandonment of plots. Plot variables such as slope and plot distance had the expected positive signs while soil fertility had a significant negative sign as predicted. The conclusion from this study is that land abandonment and other land use options are significantly different from each other and farmers land use decisions are influenced by both socio-economic and biophysical characteristics.

Three main policy implications emerged from the findings. Firstly, two types of interventions are needed. Those aimed at highly cultivable, moderate slopes and others on highly uncultivable and fragile areas. For areas that are highly cultivable and less fragile, the probability of adoption and intensity of use of appropriate agrobased interventions is likely to be very high. Highly fragile areas could require specific policy interventions that are profitable and yet allowing farmers to keep the land under cover for a very long time. Secondly, policy makers should not seek to target their interventions only to young

farmers' and less educated farmers, as both age and farmers with primary education categories are associated with less abandoned terraces. Lastly, policy makers at all levels should provide farmers with incentives aimed at minimizing distances to plot fields (e.g. through land exchanges) since distance to plots significantly influences farmers decision on which plot should be left idle despite its inherent potential to be cultivated.

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CHAPTER ONE: INTRODUCTION

1.1 Background

Uganda's economy depends on rain fed agriculture and it plays a major role as an engine for economic development. Therefore, as a necessary condition for economic growth, agricultural transformation is expected to ensure a large and increased productivity for both domestic and export needs. It should also create employment for the increasing labour force. Currently, agriculture employs over 80% of Uganda's work force. The agricultural sector accounts for 42% of gross domestic product (GDP) and 90% of total exports (Ministry of Finance, Planning and Economic Development (MFPED, 2005). Although the country has potential to produce food crop surpluses, the production of food crops has greatly declined. The background to the budget (2004-2005) revealed that 5% GDP growth was realized instead of the estimated 7% because agricultural food production had declined (MFPED 2005).

In Kigezi highlands, South Western (SW) Uganda, pressure for intensification of agricultural production has increased. High population growth and income needs fuel the domestic demand for agricultural products. Farmers appear to have responded to these pressures by using more labour and capital per hectare of land as predicted by the theory of induced innovation (Boserup, 1965; Hayami and Ruttan, 1985). (In this thesis, the following words; farmers, peasant farmers and small-scale farmers are used interchangeably). As farmers are driven to intensify, the key emerging issue in Kigezi highlands is that the type of intensification pursued may be unsustainable. Low crop productivity is prevalent and is partly the cause of poverty for most rural households. There is a large and growing gap in the agricultural labour productivity of terraces under different land use systems (Appendix 1). Soil erosion and declining fertility have become fundamental production constraints in this area. The topsoil losses can range between 20-500 tons/ha/year (Kakuru, 1995; Tukahirwa, 1995; Bagoora, 1998; Siriri, 1999). Soil control devices such as terracing, strip and contour planting are known by farmers but are seldom practiced both individually and collectively on large scale. Very little soil replenishment takes place either in form of organic or commercial fertilizer.

Consequently, the development of the agricultural sector in Kigezi has involved progressively more intensive use of labour and mining of land resources for cropping and grazing. This practice involves unsustainable adaptation and changes in land use. According to National Environment Management Authority (NEMA, 1998), Kabale district is intensively cultivated and has the highest potential of degradation and terrace abandonment because of over cultivation on steep slopes, high population densities and annual crop cultivation. Previous studies in Kabale district revealed that some of the terraces that appear to be in long fallow could in reality be abandoned (National Union of Researchers and Research Users in Uganda (NURRU, 2001); Lindblade *et al.*, 1998; Agroforestry Research Networks for Africa (AFRENA, 1999). Terraces that are abandoned for long without productive activities make land lie idle for a number of years rendering them economically undesirable (see Appendix 2). As a result, farmers appear to opt for different land use systems intuitively but there are no previous studies revealing why farmers tend to take these decisions. Therefore understanding the causes and consequences of widely, differing land use patterns and intensity in Kigezi is critical for agricultural development and natural resource policy decisions.

1.1.1 Description of the Kigezi highlands

The Kigezi highlands are a region of high agricultural potential with a high population density (250 persons Km^2) and population growth of about 2.2% per annum (MFPED 2004). The most densely populated areas in Uganda with population densities beyond 250 persons per Km^2 include Kampala, Jinja and Mbale District. The specific study area is Kabale District in Kigezi highlands. (In this study, Kabale District and Kigezi highlands are used interchangeably). Kabale District lies at an altitude of 1500-2700 m between latitudes 1'S to 1'30'S and longitudes of 29' 35"E to 30' 43" West. Its total land area is about 1850 km^2 . It receives a bimodal rainfall ranging from 1000 to 1500 mm. The temperatures are moderate with mean minimum of 13⁰ C and mean maximum of 23⁰ C. Kigezi has generally volcanic soils that are inherently fertile but some areas have less fertile Ferrasols and Andosols (Djimbe and Hockstra, 1988).

Subsistence farming takes place on fragile lands mainly in form of steep slopes ranging between 5–60%. Peden (1992) noted that land in many areas is rarely left to fallow and that which appears to be in fallow is in reality abandoned because of low crop yield potential. Research done by (AFRENA, 1999) showed that the effect of natural fallow on subsequent crops is short-lived and does not encourage farmers to re-cultivate the abandoned plots after several years. Farmers purposefully break the fertile terrace boundaries in order to pull down fertile soil that temporarily increases yields but results in unsustainable land use options.

1.1.2 Farming patterns In Kigezi highlands

The present day farming patterns in Uganda and Kigezi highlands in particular are a result of a long history of association developed from the ecological and economic interaction between man and the environment for a very long period. One such system is shifting cultivation or long fallow system locally known in Kigezi as “*Hinga raza*”. Shifting cultivation involved an alteration, between cropping for a few years on selected plots and a fallow period of several years when soil would be rested (Boserup, 1965; Miracle, 1976; Ruthenberg, 1980). Under this system, slash and burn was practiced for about 5-10 years before shifting to the next area (Kerr *et al.*, 1978). Long fallows consisted of early successive stages of secondary vegetation after a cropping period (Nye and Greenland, 1960) and were the backbone of shifting cultivation.

For generations, land fallows were used as a soil enhancement and conservation strategy in arable land use systems not only in Kigezi highlands but also in most areas of the world. The overall purpose of farmers’ decision to fallow was to allow agricultural land to regain soil fertility during rest periods. Evidence exists in Kigezi and other parts of the world that show that farmers know and appreciate the ecological and economic benefits of land fallows (Buresh and Cooper (1999). By contrast, currently, farmers in Kigezi do not voluntarily practice fallow. Partly, due to social, economic and biophysical factors such as lack of inputs, steep slopes, distance of fields from home, a serious problem of land abandonment has become increasingly common (AFRENA, 1999; NURRU, 2001).

Due to high population density as earlier noted (section 1.1.1), the demand for agricultural land has increased on fragile land, steep slopes and valley bottoms. Fallowing strategies whereby land rested for several years before reuse have changed and instead continuous cultivation is practiced with short fallow periods (Boserup, 1965; Ruthenberg, 1980). Furthermore, the production technologies have remained unchanged, while population densities, demand for food and cash have increased over the years. Arguably, fallowing as a strategy for soil fertility management has been reduced or eliminated in Kigezi.

In Kigezi highlands, as land is used intensively, with little external input, soil fertility further deteriorates through nutrient mining. As a result, some farmers resort to longer fallow periods to maintain soil fertility and forego the current food demands. Other households continue to extract short-term rents through self-exploitation and risk by mining nutrients from the current cropland. Consequently, farmers are faced with a need to balance current increased food and income demands with declining soil fertility and the need for longer periods of land rest. Since peasant farmers are known to attach a much higher preference for short-term results than long term (Ellis, 1998), the former strategy to resort to long fallow periods contradicts farmers' common approach to land use decision-making.

Unsustainable land use systems that accelerate degradation and land abandonment have negative connotations that imply loss of value for the land and associated natural resources. The lost value could be related to land productivity, which is the concern for this study and loss of flora and fauna. Agricultural land degradation and abandonment are important particularly in Kigezi highlands because:

- (i) It leads to inefficient use of terraces through a reduction in agricultural productivity,
- (ii) Farmers migrate to the frontier areas in other parts of the country and clear virgin forested areas as existing land loses productivity,
- (iii) It causes conflicts at the frontier between migrant farmers, local residents and central /local government,

- (iv) It places high demand on natural and other resources to replenish the land; and
- (v) It leads to offsite degradation, loss of productivity and amenity values.

1.1.3 Problem statement and justification

Restoration of soil productivity in Kigezi highlands has traditionally relied on natural fallow practices and subsequent natural resource regeneration. High population density of more than 250 persons/Km² in this part of the country has led to land shortage. In addition, land fragmentation caused by the system of land inheritance and adopted as a strategy to minimize risk caused by differences in soil quality and a need for a diversity of growing conditions by farmers, has increased. Cultivation takes place on the steep slopes with gradients sometimes exceeding 45° and terracing was introduced in the area as a soil conservation measure to increase production (Purseglove, 1946). Continuous downhill cultivation with absence of soil nutrient replenishment has increased soil erosion, nutrient depletion and increased incidences of poor crop yields. As a result, many of the valley bottoms once covered by papyrus swamps are drained and either replaced with pasture grasses or annual crops. Consequently, some of the land that is degraded has been abandoned.

The perceived irony or discrepancy is the existence of large portions of uncultivated land in such a densely populated area. There are a number of possible explanations for such uncultivated land. Firstly, fertilizer is unavailable and this could lead to some long fallowing (Appendix 3). Farmers try lots of other soil fertility enhancement practices, such as intercropping, crop rotations, residue incorporation and use of manure. These however appear insufficient in terms of nutrients that may be required by different plants. Secondly, longer and increased area under long fallows could be a farmers' management strategy to improve natural resource management (Lindblade *et al.*, 1998). Thirdly, plots are very heterogeneous and some areas are very unproductive in terms of crop yields despite effort to increase production. Furthermore, poor land markets could inhibit farmers from acquiring land that they could put into use and disposing of land that they have abandoned as distress sales. Despite the above hypotheses, the bio-economic

determinants, causes and extent are not understood and therefore the economic interventions to address the problem are still elusive.

Past research has emphasized the agronomic (biophysical) factors that lead to land degradation such as nutrient depletion and soil erosion (Raussen *et al.*, 2000; AFRENA, 1999; Lindblade *et al.*, 1996; Kakuru, 1995; Carswell, 2002). Arguably, the presence of a biophysical problem does not justify an economic problem. To my personal knowledge, little attention has been paid to the socio-economic factors, which play an important role in the understanding of land degradation, abandonment and farmer decision-making criteria to adopt practices to rectify the situation. There is no empirical work showing the extent and an explicit relationship between land use options and social and economic determinants. A possible reason could be the lack of adequate data to estimate the land use function. Therefore, there is a knowledge gap and little is known about the economic factors that are responsible for terrace abandonment and its extent.

The decision to rest land for longer periods than the farmers would have desired (*unintentional fallow*) locally known in Kigezi as “*Eibija*” as opposed to *intentional fallow* that is practiced when land is abundant locally known as “*Hinga raza*” is investigated (See Appendix 1). This practice of unintentional fallowing henceforth called abandonment (unintentional fallow) of farmland has also been observed in several countries including Botswana, Japan and Lebanon (Mmopelwa, 1998; Artzen, 1984; Kashiwagi, 1998; Zurayk, 1994). What are the socio-economic determinants that distinguish between farmers decision to intentionally and unintentionally rest land for long periods or put it under other options such as woodlot? Studies that test hypotheses related to intentional and unintentional fallowing in areas that are intensively cultivated within an economic context are very limited. This study investigated the determinants of farmers’ decision to use plots for crops, short fallow, long fallow, woodlots and abandon some simultaneously and provided empirical evidence into smallholder land use decisions.

The analyses used to test some of the hypotheses helped to determine the influences of important variables leading to abandonment of terraces and test the importance of different explanatory variables. Reliable estimates of the individual causal factors obtained are very important for understanding farmers' decision-making process. They also helped to predict the effects of alternative land use interventions and other policy decisions.

1.1.4 Importance of the study

This study is of importance to policy makers, planners, farmers, researchers, non-governmental organizations (NGO's), and development partners. Policy makers and planners will find the results useful in formulating policies aimed at sustainably increasing agricultural productivity and conserving natural resources. This will minimize land abandonment and long fallows by profitably using abandoned terraces. Farmers will make informed decision as a result of understanding the causes of abandonment and long fallowing and use appropriate innovations to overcome this problem. It will also assist donors and development partners to ensure that their support to government meets their primary goals of improved agricultural output, increased household incomes and sustainable natural resource management in rural areas. The study specifically contributes to the government plans to modernize agriculture, improve and sustain management of natural resources and alleviate poverty through optimal resource use.

1.2 Objectives and hypotheses

The general objective of this study is to determine the present status and causes of land abandonment in Kabale District, and propose policy options for sustainable management of land resources. The general objective is achieved through the following specific objectives:

To determine the extent and nature of abandoned and long fallow terraces, and characterize households with these terraces

To identify and quantify the plot/farm level socio-economic determinants of terrace abandonment and long fallow decisions of farmers

To evaluate policy options and incentives for efficient management of abandoned terraces

1.2.2 Hypotheses

H1. Abandoned terraces are common and differ significantly from other terraces in a number of characteristics such as location, slope, soil fertility, distances to fields, number of plots, plot size and farmsize.

H2. Households with abandoned terraces are significantly different from those with no abandoned terraces in terms of wealth, education levels, intra-household composition, and access to off-farm income, household labour availability, capital availability, age of household head and distance to roads and markets. Expected directions of the relationships for some selected variables are given below. (Details see Appendix 4)

Summary of selected variables and their expected relationships

Variable	Description	Expected signs
AGE	Age of the household head	+
Formal Education	Household heads with primary or post-primary education in relation to those with no education	+
HHSIZE	Number of household members	-
HHFEMALE	Households headed by female	+
HHPOLY	Polygamous households	-
Topographical location of plot	Whether plot is on mid-slope or top of hill in relation to valley bottom.	+
FERTILITY of SOIL	Plots with moderate or good soil fertility in relation to those with poor soil fertility	-
STONES	Plots with some or many stones in relation to those with none	+
PLOTSIZE	Plot sizes of terraces	-
SLOPE	Plots with moderate or steep slopes in relation to flat plots	+
PLOTDIS	The distance of the plot from home	+
FARMSIZE	The total farm size	+

H3. By-laws and policies to sustainably manage abandoned terraces exist but their implementation is constrained by lack of knowledge, lack of political will, farmer resistance and related factors.

1.3 Thesis approach and organization

The thesis comprises of six chapters. Chapter one consists of the introduction. It provides the background information on the conditions that prevail in the small-scale sub-sector

and to characterize the potential threat posed by land abandonment and degradation. It also provides an overview of the research problem and justification for the study. The objectives and hypotheses of the study are formulated.

Chapter two presents the review of the relevant literature on the research problem of abandonment, long fallows and the other land use options. In the review process, identification of gaps; outstanding limitations and unanswered questions in the current state of knowledge are highlighted. Chapter three develops the conceptual framework for the thesis. Using the perfect competitive model as a benchmark for agricultural production, the models for estimating the land abandonment/fallowing are developed. This chapter also develops the different approaches to explain the peasant decision-making process under various scenarios that could lead to sub optimal land use.

The research methods and procedures, the statistical and econometric analytical techniques are presented in chapter four. Firstly, it presents the econometric analytical techniques and evaluates the limitations of the selected techniques. Secondly, this chapter presents the research plan, data collection techniques and approaches used to gather data on the biophysical and economic factors related to abandoned terraces. Furthermore it describes the sources of data on abandonment and other land use options

Chapter five presents both the results and discussion. Firstly, the descriptive results on the extent and characteristics of abandoned terraces are presented. Secondly, it compares results of the socio economic characteristics of farmers' with abandoned and non-abandoned terraces based on descriptive statistics. Thirdly, regression results are evaluated through hypotheses testing. The alternative models to predict factors affecting the area of abandonment are presented. Lastly, the results from the farmer meetings related to institutional reforms, constraints and farmers commitments to improved use of abandoned terraces are integrated with the reviewed experiences to identify the most feasible alternatives.

Chapter six presents the summary and the conclusions drawn from the analysis. The policy related recommendations made regarding the future use of abandoned terraces are also presented. The research limitations and areas for further research are noted. Finally the references cited and appendices are presented.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Land degradation and abandonment has been studied in several ways. Firstly, several studies have examined the economic determinants, adoption of conservation practices and farmers perception of these practices (Shiferaw and Holden, 1998; Thatcher *et al.*, 1997; Cornway and Barbier, 1990). Secondly, some studies have investigated the economics of restoring degraded land back to productivity (Hayes, 1999; Ehui and Spencer, 1993). Several studies have examined the economics and determinants of land degradation, (Barbier, 1998; Greton and Salma, 1997; Bojo, 1991), abandonment (Mmopelwa, 1998; Kashiwagi, 1998) and fallowing (Grisley and Mwesigwa, 1995; Grisley and Mwesigwa, 1996). Lastly, several studies have examined population growth and land use based on the theoretical exposition of extensification, intensification, land use options and the related policy issues (Pagiola and Holden, 2001; Angelsen and Kaimowitz, 2001; Pender and Duron, 2001; Reardon *et al.*, 2001).

Partly, the reason for few studies may be due to the commonly held perception that reduced population growth and improved technologies for degraded areas could be the solution to degradation and poverty problems in densely populated areas especially for Sub Saharan Africa. However, the lack of concrete analytical framework on the causes of degradation, abandonment and various land use options in densely populated areas makes these recommendations elusive. Furthermore, emphasis on the biophysical variables, macro economic variables with little farm level data have resulted in inconsistent conclusions and inappropriate policy decisions. The relevant research that has focused partly on key aspects of population and land use, determinants of degradation, fallowing abandonment and some areas of population growth and land use are critically discussed.

2.1.1 Population growth and land use intensification

The relationship between population density and changes in agricultural land use underlies many theories of agricultural advances (Malthus, 1798; Boserup, 1965). The debate on this subject has been of considerable interest since Malthus pessimistic theory

that population growth rate normally outstrips the ability of agriculture to increase food supplies thus leading to economic collapse. Malthus (1798) argued that agro ecological zones have population carrying capacities, which must not be exceeded. Furthermore, he proposed that most productive land is used as population grows and the area used for agriculture expands with it. Consequently, the quality of land brought into production declines. In such cases, if farmers increased labor application it leads to a fall in mean output per worker through the law of variable proportion and consequent withdrawal.

Boserup (1965) criticized Malthus and converted the same population dynamics model into the engine for agricultural growth. She argued that exogenously determined rates of population would create incentives for agricultural intensification, thus inducing innovation and intensification of agriculture. Gradual population growth would thus become a catalyst for changes in agriculture, leading to sequences of intensification from forest fallows to bush fallows, to short fallows to annual cropping and ultimately to multiple cropping systems. However, there is a gap in this model since empirical evidence does not always support it. For example, the model does not explain the important developments in agriculture especially if degradation and abandonment of land in the intensely populated highland areas take place. Nonetheless, the model has proved highly influential because it provides a means to introduce soil fertility and technological innovation in agriculture.

Tiffen, *et al.*, (1994) using aerial photographs examined the land use in Machakos, Kenya and her results revealed that population growth had led to induced innovation and generated necessary adjustments. She noted that most bush grazing areas were converted into arable land and adequately conserved by 1990 through terracing and increased tree cover that led to growth of high value crops such as fruits and vegetables. However, while the study revealed the importance of intensive management of farming systems, it does not explain the existence of unutilized bare areas some of which have remained for a long time. Consequently, it does not give farmers' reasons for leaving such land idle.

Vogt *et al.* (2006) investigated the land cover change in Uganda integrating remote sensing and rapid appraisals. They postulate that rapid population growth, unsustainable land use, pervasive degrading landscapes and inappropriate policies are components of a dominant paradigm that persist regarding African development. They conclude that the savannas of today are derived from forests by cattle grazing and unsustainable cultivation. Secondly the savannahs are also a secondary forest regrowth. These conclusions were based on evidence of human activities in the grasslands and the assumptions that the areas were converted originally from forests. Vogt *et al.* (2006) further argue that at the end of 19th century there were numerous farms with large cattle herds. They postulate that the current grasslands are a result of a process of forest clearings followed by unsustainable cultivation and grazing, and finally abandonment due to poor resource management. However, there is lack of systematic overtime empirical studies to confirm changes in soil fertility on these grasslands (Vogt *et al.* 2006).

2.1.2 Land degradation and farmers incentives to adopt conservation practices

Barbier (1997) investigated the economic determinants of degradation in developing countries. He descriptively explored the relationship between poverty, imperfect markets and insecure land tenure and revealed that these factors tend to reinforce short-term horizon in production decision and could bias land use decisions against long-term management decisions. The key features in these processes are the failure of rural households to invest in long-term land improvements on existing agricultural land and abandonment of this land in favor of migration to forest and other marginal areas. Furthermore, Nabanoga and Gombya Sembajjwe (2001) observed that limited access to land, insufficient capital and lack of employment opportunities were the major driving forces for households' unsustainable exploitation of the forest resources.

Barbier (1997) further revealed that degradation and abandonment was neither a soil science nor plant breeding problem but purely socio-economic. Faced with marginal areas where land productivity and household income is either stagnant or declining, poor rural households with limited access to capital and alternative economic opportunities may have to extract short term rents through resource conversion, nutrient mining and

degradation in order to survive. The study concluded that current evidence suggests that existing and potentially productive agricultural land in developing countries is being lost through the process of land degradation and abandonment.

Shiferaw and Holden (1998) investigated the degradation and conservation behaviour of peasant's household in the degraded part of the Ethiopian highlands on 452 parcels using an ordinal logit model. Results showed the importance of perception of the threat of erosion problem, household, land and farm characteristics. Technology attributes and land quality differentials determine conservation decisions of peasants. Furthermore, where poverty was rampant, and appropriate policy lacking, results revealed that population pressure per se was unable to encourage sustainable land use as suggested by Boserup (1965). Degraded areas with widespread poverty, autonomous intensification of land use as response to increasing population pressure may not always lead to increased investments in land conservation. Shiferaw and Holden (1998) revealed that large population growth in Ethiopian highlands without appropriate policies could lead to further degradation. Households may invest in land quality with increasing scarcity of land only if appropriate policies and technical change are in place to ease the pressure. Otherwise, rural households may be caught in a poverty-environment-population trap that could lead to abject poverty and resource degradation. Specific policies addressing the constraints of peasants through technical change, development of rural markets and provision of appropriate incentives were recommended.

Bojo (1991) analyzed the problem of land degradation from an economic perspective with particular attention to the situation in developing countries. He evaluated how economic analyses can contribute to efficient land use and rehabilitation using descriptive analyses and reviews of available evidence of land degradation. He examined the driving forces behind degradation in terms of the extent of land degradation using physical assessments, financial and economic assessment, such as market and policy failure that either contributed to land degradation or hamper effective countermeasures. He concluded that financial and economic assessments are few for developing countries and market and policy failures contribute to the deviation between privately and socially

optimal behaviors hence leading to distortion. Policy failure and suppression of information contribute to the lack of progress in the work of to improve land management. Bojo (1991) further revealed that at macro level, it was necessary to trace the impact of general policy on land management.

2.1.3 Degradation, fallowing, abandonment and farmers land use decisions

Mmopelwa (1998) empirically investigated the proportion and factors causing unintentional fallowing in SE Botswana. He used data from 100 randomly selected farmers and simple statistical estimations. In particular, the study revealed that 20% of farmers unintentionally fallowed, 1% intentionally fallowed and 79% did not fallow at all. The factors attributed to fallows were the lack of draught power (86%), labor (82%) and rainfall variability (100%). Based on these findings two aspects of fallowing could be noted. The first aspect is intentional fallowing, in which farmers purposefully leave their land uncultivated for it to regain soil fertility. The second aspect is that of unintentional fallowing whereby farmers involuntarily leave their land uncultivated due to biophysical, social and economic factors beyond their control.

Grisley and Mwesigwa (1995), examined the socio economic determinants that influence short fallowing in Kigezi highlands. Specifically, the study empirically involved the statistical estimation of the short fallowing as a function of field size, hours worked on farm, plots on hillsides and distance from homesteads and the effect of these variables on short fallowing decision by the farmer. The methodology used was based on the concept of utility maximization function hypothesized by (Chambers and Foster, 1983; Rahm and Huffman, 1984). The tobit framework was used as the dependent variable was censored with values that range from 0-100. Grisley and Mwesigwa (1995) revealed that 76% of farmers reported some cropland in grass fallow. Farmers reported an average of 26% of cropland under fallow. Model estimates revealed that intercropping and farmsize were highly associated with land fallowing decision but distance to fields was not. Grisley and Mwesigwa (1995) recommended use of capital-intensive technologies such as terracing, agroforestry and use of chemical fertilizer though currently unavailable. On a longer term, they suggested evaluation of these options, since use of unmanaged grass fallows

was insufficient to maintain soil fertility. The research investigated factors determining short fallowing only but disregarded other land uses such as long fallowing, woodlot, and abandonment. Furthermore, it estimated the relative changes in short fallowing rather than absolute levels of plots under different land use system. Therefore, information on factors that could influence farmers' decisions to use different land use options is limited.

Grisley and Mwesigwa (1996) investigated the socio-economic determinants of long term fallowing using 36 households from West Nile in Uganda. They empirically explored the relationship between fallowing as a function of demand factors such as soil fertility and erodability factors, management and technology factors, and household and income. Linear relationship was analyzed using variables such as area of land in crop, age and farm size. The model estimates revealed that a decrease of 268% in net total fallowing would occur if population doubled. It was concluded that fallowing is related to the age of farmer as well as farm size and there could be a significant mining of soil nutrients and increase in soil erosion if no appropriate technologies are used.

An empirical work by Barbier (1998) used a linear programming model to investigate the induced innovation and land degradation in the intensively cultivated areas of West Africa. The results of the model showed that farmers prefer extensification to intensification even if land is marginal and yields are low. Under population pressure, the model revealed that overtime soil organic matter and soil nutrients become scarce and the cost of land degradation increases. The cost consists of loss in yields, loss in cropped area due to abandonment and increased costs of soil conservation practices, which include labor and cash costs. Furthermore, Barbier (1998) argued that in such cases the most effective way to maintain productivity is to abandon the overused area and cultivate new land. However, if the population is constrained to stay in the area, the economic outputs and welfare deteriorates especially when existing markets and technologies for agricultural improvements are limited (Bilshborrow (1987)).

Lindblade *et al.* (1998) and Carswell (2002) investigated the changes in land use system in Kabale District between 1945 and 1996 and 2001 respectively, as well as the current

farm management practices. They used transects conducted in 1945 as baseline for measuring land use changes and systematically interviewed farmers with plots along the transects concerning their management practices at 1 mile interval. Both authors observed significant increase in area under fallow since 1945. For example, 19% of plots were left to fallow in 1945 as compared to 32% in 1996. Results suggest that the length of time the fields rested had extended significantly with 95% left to fallow for more than half a year in 1996 compared to only 5% in 1945. Households with more than 11 plots reported 31% of their plots under fallow while farmers with less than 5 plots could fallow up to 25%.

Furthermore, woodlots rose significantly from 3% to 22 % on the <20% slopes and from 7% to 27% on slopes of 20% and beyond. Farmers' reasons for the increase in use of land for woodlots were not investigated. Based on these results, Lindblade *et al.* (1998) concluded that farmers fallowed more land than they did fallow 60 years ago because it helps maintain soil fertility. Lindblade *et al.* (1998) also suggested that the system could work better if the land was left for sufficiently lengthy period of about 10 years, much longer than fields are left to fallow in Kabale. This suggestion raises several issues. This contradicts the intensification model (Boserup 1965,) that suggest that when there is no more land for extension, farmers intensify by reducing fallow to periods less than one year. The methodology used by Lindblade *et al.* (1998) comprised mainly following transects and the analysis involved descriptive statistics. This explained only what had happened over the years but could not explain why farmers leave more land for longer fallow periods now when population pressure is higher. This study used a stylized modeling approach to farmers land use decisions to understand this contradictory issue.

Namalwa (2000) investigated the profitability of deforestation in Mpigi District in Central Uganda. She observed that low input of commercial fertilizer and other types of technologies such as high yielding varieties and soil conservation measures dominate Uganda's agriculture. On average 35.5 of the respondents fallowed their land for one year, 24% fallowed land for less than 1 year and 40% did not fallow their land. She observed that fallow periods had drastically reduced by not less than 2 years as compared to five years back. These changes were associated with the desire by farmers to intensify

cultivation for subsistence and commercial production. However, Kamugisha (1993) stated that cultivation for annual crops traditionally included fallow periods but due to an increase in population, these fallow phases had been continuously shorted to less than one year or even completely eliminated altogether in some areas.

AFRENA, (2004) revealed that nutrient levels are low on most plots especially on the upper part of the terrace. Only thirty percent of the plot (lower part) produces over 80% of the yields on most plots. In some cases, 50% of the upper terraces are left uncultivated for several years due to lack of adequate nutrients. Again, recent investigation (Raussen *et al.*, 2000) revealed that natural fallow cannot restore soil fertility back to original levels after 2- 3 years. Hence, they proposed an increased adoption of short rotation fallows to improve and restore soil fertility on cultivable fallows if cropping was to be done and adopt rotational woodlots for uncultivable fallows.

Furthermore, finding more fallow and abandonment of plots in Kabale district is perplexing given the perceptions of the local people. Rapid appraisal exercises conducted by various researchers (NURRU, 2001; AFRENA 1999; Bamwerinde *et al.*, 2000) revealed consistently that the perception of local people is that land fallow periods have decreased or are non-existent for some farmers. No previous work has investigated the discrepancy between researchers findings and the theory of induced innovation (Farley, 1996; NURRU, 2001; Lindblade, 1998; Bamwerinde, 2000). It is probable that yields have declined tremendously and farmers are abandoning former croplands in favor of high yielding options either in form of off-farm employment or out migration.

2.1.4 Sustainable and unsustainable land intensification

Reardon *et al.*, (2001) investigated the issue of sustainable and unsustainable intensification pathways. Their study revealed that when there is growing pressure for intensification, farmers respond by using more labour and capital per hectare following the theory of induced innovation (Boserup, 1965; Hayami and Ruttan, 1985). However, as rural farmers are driven to intensify cropland, the type of intensification they use could be either sustainable or unsustainable depending on the prevailing factors. For example,

Reardon *et al.*, (2001) argued that rural farmers could take the unsustainable path in the absence of financial institutions, market, and policies that minimize constraints faced by farm level decision makers. (Ehui, 1992; Romero, 1993; Anderson, 1994) using modeling techniques observed similar results. They proposed that capital formation coupled with improved technology was the means to keep agricultural output ahead of population growth. As a result, their studies concluded that investments into the fragile populated areas remain the key to increased productivity in the intensely cultivated areas.

Smalling (1993b) examined population pressure and land use and observed that as population grew in Sub Saharan Africa over the years, new lands for clearing became scarce and land under cultivation became less productive due to reduction in fallow periods and subsequent land mining. This leads to a shift in sustainable agriculture, as farmers need to start investing in land enhancing technologies in addition to labor enhancing technologies. In the absence of capital to invest in intensification, Smalling (1993b) argued that farmers resort to capital deficient approaches that severely threaten the productive capacity of the natural resource base. Over time this type of intensification depletes soil nutrients and cannot be sustained without shifting to capital led investments such as inorganic fertilizers. Insufficient use of capital combined with intensive land use characterizes most of the hillside in Africa today that has led to soil mining, degradation and abandonment.

Lapar and Pandey (1999) examined the issue of soil degradation in the sloping uplands of Asia. The limited success of soil and water conservation that led to poor land use revealed that farmers objective in land surplus situation was to expand the area rather than improve yield. As a result, land quality suffered due to lack of investments over time leading to field plots being rested for a long time. During the long fallow periods, soil fertility could be restored sufficiently to allow re-cultivation. Lapar and Pandey (1999) argued that although long fallows and investments in soil quality could improve productivity, for farmers to do so depends on economic incentives in place. Where such incentives are lacking soil degradation will continue until out-migration reduced the population pressure or the area itself is abandoned. Their study concluded that if factors

such as poorly defined property rights, less developed markets accesses are the norm, and agro climatic condition are poor, soil degradation continues until land is abandoned.

Pattanayak and Mercier (1998) investigated the extensification of land use as a means of enhancing sustainability and concluded that it was no longer an option in the densely populated areas of Asia and therefore land needed to be intensified to feed the increasing population. However, intensification of land use depends on the level of development of both capital and land markets, access to information and technology and development of the non-farm sector. In the absence of the above, a mining strategy based on rapid exhaustion of soil fertility and land abandonment can be adopted (Fugisaka, 1989). For example, Philippines farmers grew food crops in logged areas for few years and abandoned the fields afterwards because they had no incentive to conserve the productive capacity of the fields. The migration of the population to the uplands in the 1970 and 1980s has been attributed to the stagnant productivity of rice in the lowlands, a high population growth and a poor non-farm sector. Similarly in Vietnam, the government policy of regional food sufficiency until late 1980s was a major factor for the expansion of the areas under shifting cultivation and the consequent abandonment of farm plots Lapar and Pandey (1999).

Greton and Salma (1997) investigated the links between different forms of land degradation and agricultural output and profitability in Australia. To determine the index of degradation, they adopted the method suggested by Walpole *et al.*, (1992) to rank the severity of degradation using a snapshot data. Results suggested that farm management and technology, agricultural outputs and profits vary depending on the different types of degradation. Increased soil acidity and soil structure decline indicated lower levels of production and led to degradation of the land. Results further indicated that as the extent and severity of irrigation salinity increased, a substitution from cropping to grazing activities increased. The study concluded that for a better understanding of land degradation, knowledge is needed of the biophysical causes, the economic effects on farms and the incentives farmers face to avoid the degradation.

Bilshborrow (1987) reviewed case studies of population, land use and environment. His results indicated that there were growing signs of limitation to intensification as the cost of intensification rose especially in areas with serious soil erosion and terrain constraints. Furthermore, it was revealed that households exhaust the economic options through land intensification. If these results prove inadequate then seasonal migrations take place since this option does not involve giving up the land completely. If the problem persists, permanent land abandonment or out-migration follows the form of either rural urban if wages are higher or rural-rural for frontier. The study concluded that policies that help rural farmers to intensify production through more technical assistance and credit to raise crops rather than cattle could solve the problem.

When soils degrade due to nutrient depletion, the traditional cycle of shifting cultivation accelerates, limiting the necessary regeneration of soils hence undermining the objective of sustainable intensification. Practices such as fallowing can be good for the environment in meeting household needs but if they are not profitable, the farmer will just ignore them (Pagiola, 1995). Sustainable agricultural intensification should enhance the resource base of farmers and thus improve the productivity as well as the financial profitability to meet the farmers' production goals. Even when it is environmentally sustainable if it is not profitable, intensification fails to attain the reservation levels of food and cash and lead farmers to the marginal areas to make up for the gap in production and hence undermine the environmental benefit by harming the fragile margins.

2.2 Household decision making environment

A number of factors influence the decision-making environment in which households operate. They are broadly categorized as either external or internal to the households (Sadoulet and de Janvry, 1995). Physical and biological environment such as natural resource conditions, pests and diseases and the set of available technologies are among the external factors influencing household decision-making. Other factors include the external environment faced by households such as a set of collective assets owned by producers, infrastructure, markets and price incentives. Off farm activities, are pursued by households both because they lack access to sufficient land to make agriculture a

viable income strategy and because market failures for credit push them to off farm activities to diversify their risks and seek sources of liquidity to be used in agriculture (De Janvry and Sadoulet 2001)

The household internal asset base conditions its behavior and how they can practice sustainable agriculture. Assets take many forms such as natural capital that consists of land and soil nutrients. Physical capital includes transport, roads. Financial capital includes cash and other liquid assets, credit and other inflows such as gifts. Human capital consists of education, skills and knowledge. The understanding of how some of these assets influence land use options could prove central to efforts to track both the environmental and financial sustainability of land resources over time.

The tracking of biophysical factors over time provides the means of extrapolating from farm level case studies to whole farm impacts by revealing the tradeoff between the asset allocation across the various options and the consequent impact of growth in one commodity and other various activities. An important distinction made in this framework is between the biophysical and economic variables. In this study, farm households are assumed to be individual economic units who individually make decisions to maximize returns from given land use options given the resources available.

Previous studies (Raussen *et al.* 2000, Kakuru 1995), in Kigezi related to land use were mainly confined to the biophysical causes of degradation and the technical alternatives to overcome the problem and improve the livelihood of the population in the intensely cultivated areas. These approaches were based on the premise that lack of technologies to address the biophysical causes is the root cause of insufficient production in densely populated areas. Hence, economic factors were less emphasized partly because of lack of a concrete conceptual framework to investigate them. The primary fault with this approach is that it limits policy makers to biophysical solutions alone. For example, previously, policy makers have emphasized use of soil conservation measures such as terracing rather than understanding the socio-economic aspects of households that practice them.

CHAPTER THREE: CONCEPTUAL FRAMEWORK

3.1 Introduction

The approach used to investigate the problem of terrace abandonment in Kabale district agricultural production system is to take as a benchmark, the rate of abandonment, which would be generated by competitive market processes under the ideal conditions of neo-classical theory of the firm (NTF). Under such circumstances, farmers are assumed to maximize profits subject to a given technology, prices and other related inputs such as capital and labour. In this case, farmers are also assumed to make choices that are privately optimal as they make decisions as to which land use option to use. However, the concept of optimality will be limited for some aspects. The problem arises when farming involves issues of market failures and when people set values on environmental goods, but have no markets to which they can express their demands. Subsequent sections will further conceptualise the links between economic profitability and the different land use options in Kigezi highlands.

3.1.1 Unsustainable agricultural land use options

In this study, the critical baseline used to distinguish a fallowing strategy from abandonment of terraces by farmers' is through use of farmers' production goals. This criterion has both environmental and economic perspectives. For example, from the environmental perspective, if a plot is left to fallow it should enhance the resource base and improve land productivity during its time under rest. From the economic perspective, this same plot should generate financial returns profitable enough to meet farmers' cash and food demands in the short and medium term (5-10 years) after resting. Failure for the plot under fallow to meet these goals will lead to farmers ignoring the practice.

The fallowing debate and previous studies have largely focused on the environmental side. This study argues that this is insufficient for even if the fallowing strategy was environmentally sustainable, if it is unprofitable, farmers will not see it as a viable option and therefore will not adopt it. Furthermore, if it fails to meet the minimal requirements of food or cash, farmers will either migrate to the frontier and fragile areas to fill the gap in production, which will furthermore harm these areas (Reardon *et al.*, 2001). Under the

present conditions of increased population density, growing demand for food and declining soil fertility in Kigezi, satisfaction of food security, environmental and financial goals may require an increased input of capital. Therefore, a shift from labour enhancing to land enhancing options is expected since capital deficient intensification is currently practiced (Reardon *et al.*, 2001).

The strategy or practice of abandoning former croplands occur when farmers depend on labour, unassisted by improved technology to increase land productivity on a given unit of land. Prior to that, farmers tend to crop more densely, practice multiple intercropping, and harvest intensively. With time, this practice depletes soil nutrients and cannot be sustained without capital inputs such as fertilizers. Failure to meet food and cash demands forces farmers to abandon the plot and move to the fragile areas where the process is repeated (Byerlee, 1980). For example, sorghum as an enterprise occupies about 70% of the landscape in Kigezi. If it is based on fallowing strategy to increase productivity, labour use is likely to be unprofitable compared to alternative uses of labor off-farm. (Low, 1993; Reardon and Islam, 1989; Byerlee, 1980) have observed similar findings.

In situations where land constraints are common and labour/land ratios are rising, one expects farmers to intensify technologies that demand labour, which is the abundant resource (Reardon and Islam, 1989). However, this could work if the labour is used for agriculture only. In the presence of multisectoral rural economy, if off farm employment pays more than farm labour and helps to reduce income risk, farmers may ignore labor using agricultural technologies even in the face of farm labour surplus and opt to work on farm. Low (1993) observed that farmers in Botswana chose deliberately labour saving technologies in order to free labour for high yielding non farm work. Non-farm work may pay more highly per day and provide a means of stabilizing incomes and smoothening consumption through activity diversification (Kelly *et al.*, 1993; Clay *et al.*, 1995). Consequently, the economic criterion for profitable practices to the farmer is the most important issue that this thesis focuses on.

3.1.2 Farmers' incentives and agricultural land use options

At an individual farm level, a decision to use a given plot for current production or to put it under other land use options such as long fallow and woodlot could take place if the net present value of the option to the farmer justifies the costs given the applicable discount rates. For example, continuous cultivation with short duration fallow practice would only continue if normal returns on fixed capital would be obtained after all farm running costs have been paid. Here, it is argued that continuous crop production and short fallow involves investments of a short term in nature (0-1 year), and results in optimal use of the plot if well managed. However, since land resources get depleted, potential future profits also get reduced until ultimately the plot is fallowed or left for some other land use options that would be less profitable in comparison to cropping if land was not degraded.

Fallowing is a land management strategy to increase soil productivity in the short to medium term (1-5 years). As a result, putting land in fallow is considered to be an investment decision (Franzel 1999). This study tested the proposition that not all farmers can afford a long-term investment in fallow (>5 years) in Kigezi highlands and therefore some of the plots that appear to be in fallow could in reality be abandoned due to unintentional sub-optimal use of the plot by farmers. The complexity between plot abandonment and long fallowing is that both practices appear to be interrelated but based on different decisions. I therefore examined long fallow, woodlots and abandonment decision by farmers as different forms of long-term investment. Two assumptions were made. Firstly, in the short run farmers make decisions about their output and input mix given the set of product and input prices in such a way that their expected variable profits is maximized. Secondly, farmers exhibit a profit maximizing behavior and operate in competitive markets, hence motivated by profits in allocating plots to various options. Since the study dealt with peasant farmers, who are partially integrated in the market, the assumption was later relaxed and examined how farmers make decision when markets are imperfect.

3.1.3 Farmers' decision making process for land use options

Figure 3.1 summarizes the farmers land use choices in Kigezi highlands. Farmers' decisions on land use options were classified as continuous cropping, short fallow, long fallow, woodlots and abandonment. The use for the plot, expected duration of each option, typical vegetation on the plot and expected by-product could be done partly intuitively supplemented by experience, assessment of soil quality, yield expectation, markets and household current and future needs.

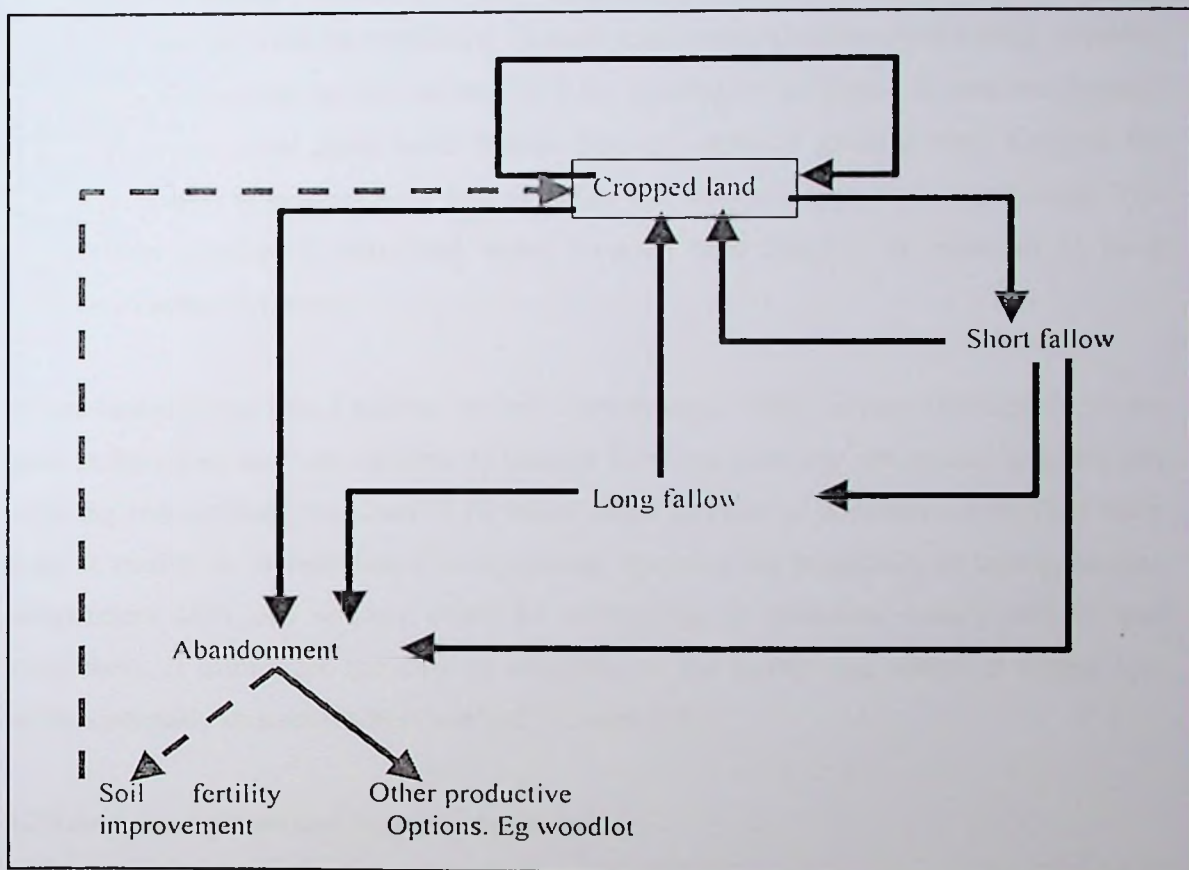


Figure 3.1: The conceptual model of the nominal decision making for land use by farmers

The process begins with the premise that poor yields, risk aversion, poorly enforced property rights, and resource constraints leading to abandonment and long fallow decisions are critical elements to household decision. For some households the abandonment takes place immediately after cropping the plot when the returns are

persistently lower than the critical minimum expected or if labour is not available for far fields. Alternatively, it may first be short fallowed, then long fallowed and abandoned.

Farmers may also opt to abandon soon after a short fallow while others could opt to do everything at once or use all plots depending on social and economic conditions of the household and biophysical factors of the plot. In some cases, farmers could revert land under abandonment back to cropping depending on the availability of inputs. For example, if soil fertility improvements are done, farmers can use some of the abandoned terraces for cropping. Therefore depending on the soil amendments such as improved fallows or use of artificial fertilizers, farmers can revert abandoned and long fallowed land back to cropping. In this model, land for grazing as an option is less emphasized because in most rural areas local breeds have no definite grazing area. Grazing for improved breeds is practiced on fenced farms but very uncommon in rural areas. The fenced farm practice is classified under cropped land since it is expected to be a continuous annual practice.

Where farmers may find it hard to use soil amendments, some farmers could prefer to put plots under other land use options. If farmers view the land use options as separate and requiring independent decisions to be taken either at once or simultaneously, then these must be treated as independent choice options. Ignoring the possibility of taking them as independent land use options could be misleading to planners, policy makers and researchers. It minimizes the choices available to the farmer and makes it appear that he/she optimally utilizes his/her land and is better off.

3.2 Land use options and farmers decisions

In Kigezi, with a given technology, the economics of land use option by farmers is assumed to depend upon farmers decision to produce or invest in other options takes place within land scarce scenario. Farmers undertake different land use options in order to increase the economic productivity of each unit of agricultural plot. Capital investment in each option when combined with production technology and management should yield a flow of returns to households in form of food for consumption and surplus for income.

Land is expected to be a source of wealth. When land is abundant, factors such as labour and capital are the major constraints to increase production through area expansion (Grisley and Mwesigwa 1995). When land is scarce, the availability of land is itself a constraint to production and this makes farmers take different decisions for each scenario. First, I analyzed farmers land use decision when land is not limiting.

Assume an individual farmer in a land abundant area who operates in competitive product and factor markets, with the goal of maximizing profits. Factor inputs, capital and the condition of the soil and other natural conditions such as weather will determine the output of the household. If the farmer has several plots and enough inputs, the profit-motivated farmer will put all land into production if the expected returns are high. He will continue to cultivate the plots on assumption that soil fertility is uniform and other factors are constant e.g distance, location. The argument here is that the farmer will equate marginal value product to the marginal factor costs ($MVP = MFC$). No land will be left to lie idle. However, under normal circumstances, to maximize total revenue, farmers would maximize returns to the scarce factor (land, labour or capital). So, if land were scarce, maximizing returns to land might lead to optimal revenue. But this depends on whether there are alternative uses for labour. If households can also work off the farm, they may prefer to seek high returns to labour by working off farm in order to maximize income and leave land to lie idle. If there are ample labour opportunities, then labour should become the scarce factor on farm leading to a scenario similar to when land is scarce.

In a land scarce situation, it is common for farmers to possess several plots that differ in soil fertility because of inherent differences in soils from one plot to another and lack of cash to apply inputs. Since production is intensive, farmers are expected to cultivate all plots to maximize output. If the discounted expected returns from the same plot followed for two years are not attractive, the farmers' response could be to abandon the plot.

3.2.1 Farmers land use decisions when plots differ in quality

The previous case is based on the assumption that farmers operate in competitive product and factor markets. Therefore, if faced with differing land qualities in land scarce

scenario, it is expected for a farmer to put the land into fallow again and invest in technologies to increase output from fallow plots much faster. This decision is however feasible only when the farmer has access to capital and technologies that shorten the fallow periods so that the farmer has access to the same piece of land as soon as possible. Ricardian approach to rent is used to demonstrate farmers land use decision (Hartwick and Olewiler, 1997) as follows.

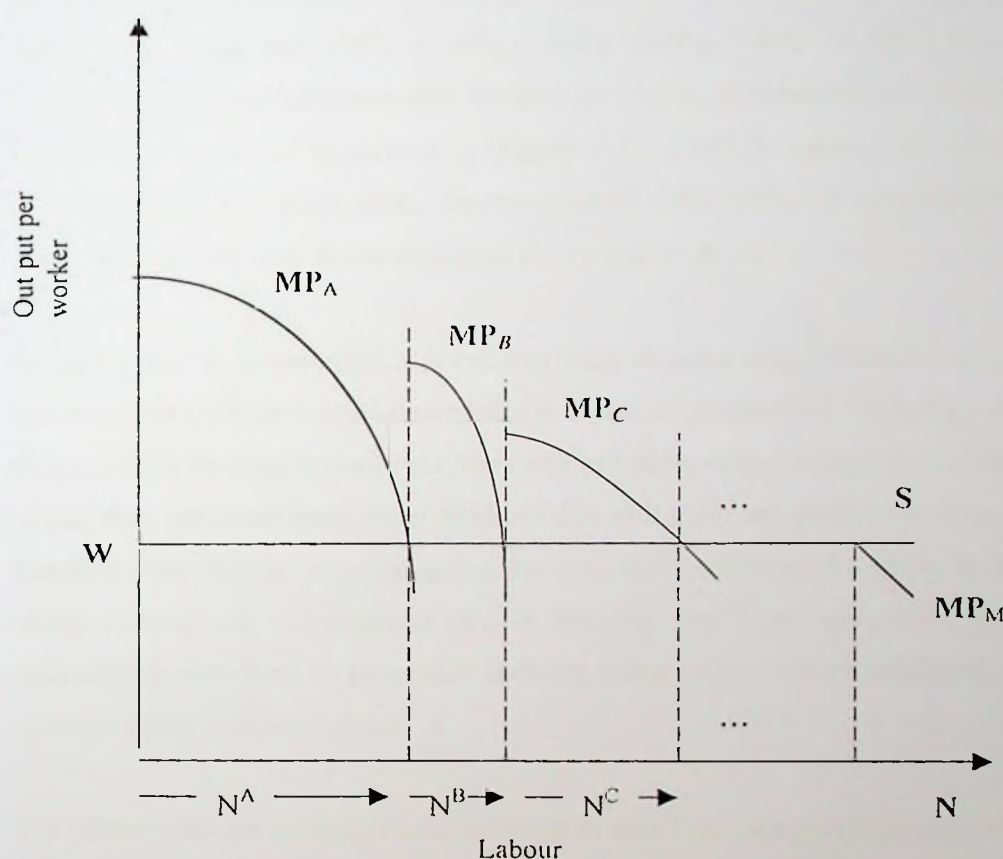


Figure 3.2: Marginal productivity per worker for plots with differing soil fertility (Hartwick and Olewiler, 1997)

In figure 3.2, N^A , N^B , N^C , N refer to decreasing marginal returns to labour as a result of decreasing soil fertility, W is the wage rate, S is the supply of labour that is assumed to be perfectly elastic at wage W . Assume that there are plots A, B, C D and E, with different land qualities. Plot A is very fertile, plot B is medium, plot C is fair, D is poor and E is

very poor. If the same level of labour for each plot is assumed, the marginal product of labour for plot A, will exceed the marginal product for plot A (MP_A), and plot B (MP_B) will have a higher marginal product than plot C (MP_C), for the same level of inputs. That is $MP_A > MP_B > MP_C$, etc. However, this difference in plot quality may not mean that only plot A will be farmed.

A profit-maximizing farmer will allocate labour to the plot until the marginal value product (MVP) of the laborer on each plot is equal to the cost of the marginal cost of the labourer or wage rate. $MP_A = MP_{AL}$, $MP_B = MP_{BL}$, $MP_C = MP_{CL}$ etc = Wage rate. Consequently, more labourers may be used for plot A, compared to plot B. For plot A the total rent is higher as illustrated in (Figure 3.2), while for plot C the labour used only covers its cost. For poor plots, the net product ($MP = MC$) is approximately zero and ($MP < MC$) at very low levels of labour for very poor plots.

In such cases, it is assumed a priori that only farmers who maximize rent will tend to cultivate plots whose marginal products is equal or greater than the marginal costs. Since they are keen on maximizing rent, they will put plots whose marginal products is equal to or less than zero into some other land use that will generate greater economic rent such as woodlot. This they do on assumption that they have access to resources to invest and can afford to take risk to maximize rent in the long run. They expect the future marginal returns from woodlots to be greater than the marginal cost of establishing them on these unintentionally fallowed plots.

The above analysis pertains to the decision to cultivate in a given season and so is not an analysis of the long run marginal product and cost. Thus, if the $MP < MC$ even at very low labour input, the farmer may put a plot into fallow if there is a good chance that a fallow will shift the MP curve upwards in a short period of time so that it will be profitable to cultivate it. For fields that may not respond to fallows, woodlots can be chosen. However, woodlots can also be chosen for their income alone, because in the longer run they may provide more income than a crop, especially in terms of returns to

labor. The long fallow decision (or abandoned) is harder to explain in the model but for one would reflect poor land markets and other means of saving.

3.2.2. Decision making under uncertainty

If the farmer operates under limited input availability and uncertainty, the nutrient depleted plot may not be used for current production. Under certainty, economic rationality in pure neoclassical sense demands that the farmer decision are to maximize profits and should operate at the point where the marginal value product is equal to marginal factor costs ($MVP = MFC$) (see Appendix 5). When farmers' decision is based on uncertainty, they attach different degrees of probability according to their subjective beliefs of the occurrence of the event such as drought. Farmers no longer equate the marginal returns to expected marginal costs (unless they are risk neutral) and will only be prepared to bring plots to production if only the expected marginal returns are greater than marginal factor costs ($EMVP > MFC$) (Ellis, 1998).

Essentially, risk averse farmers treat high variation in expected benefits as a cost that must be compensated for by higher mean returns. If the distribution of the returns is not highly variable around the mean, then marginal benefits need not be much higher than marginal costs for the risk averse. However, the expected marginal value product (MVP_E) shown at point A (Appendix 5) is above the marginal cost. Therefore, it is proposed that risk aversion causes a situation where on average MVP must be greater than MFC. Consequently, a farmer will abandon plots or he will not be motivated to cultivate them better based on his/her subjective decision.

If such returns from these plots are not equated, and soil infertility is observed to contribute greatly to abandonment then farm investment in agro related technologies would be justified to help the farmer restore the soil fertility lost. This would help the farmer to equate current and future returns. However, if the problem were not highly associated with soil fertility, other alternatives such as sale or exchange of the plot could be considered.

Therefore, there are rational reasons why under profit maximization, farmers do not fully utilize all their land. In the event that there are no incentives in form of inputs to invest in terracing, improved fallows, or fertilizers to reduce the extent of unintentional fallow plots, and no regulation in form of appropriate policies and by-laws, the household could decide to abandon the plots and migrate to the land abundant areas. Other household decisions could include the option to work as a casual laborer or seek off-farm employment within or outside the district to compensate for the apparent loss due to unplanned fallow. In such a case, the opportunity cost for such plots in the short and probably long run could be assumed zero from a labour point of view. However, despite the above argument, the opportunity cost of such a plot could arise only if the farmer could sell the plot and invest her/his revenue in assets that give higher returns.

In conclusion, several factors including imperfect markets, farmers' attitude to risky situations, input availability appears to influence farmers' land use decisions in Kigezi highlands. There is a range of issues that limit the relevance or applicability of the perfectly competitive theory of the firm in Kigezi. These include malfunctioning agricultural production factor and output markets, poverty, uncertainties, poor access to information, externalities, unenforceable property rights and ineffective by-laws and policies. For example, private decisions are not likely to be socially optimal when there are externalities temporally (using land in a particular way that could affect future generations) or spatially (when use of land could affect other land users through water and soil movement that may introduce erosion).

3.2.3 Land valuation, accessibility and competing land uses for plots

The previous section analysed farmers' decision in relation to differences in soil quality and the relevance of competitive factor markets. This section analyses how farmers attach value to the plots of land based on other factors such as plot accessibility and other competing land use options. For example, the economics of land in a land scarce scenario where land use options are competitive involves pricing of land in its best use and determination of economic activities to the various sites. This involves the determination

of the option that bids the highest rent for a particular plot (Hartwick and Olewiler, 1998).

Assume that there are plots of homogeneous agricultural land, some in the valley and others on hilltop. As usual, the output has to be transported home or roadside before transporting to local market. Furthermore, assume that the price of the produce such as potatoes at the local market is p shillings per delivered unit, c is the unit cost per distance travelled. At the production site (the farm), $(p-cx)$ is the farmgate output price, where x is distance from home/road or market. Let l denote the acres of land and n denote the number of workers to work on these plots. Then given a simplified two input production function $f(n, l)$, the efficient use of inputs of land l and labour n should satisfy:

$$\begin{aligned}(p-cx)df/dn &= w \\ (p-cx)df/dl &= r(x)\end{aligned}\tag{3.1}$$

df/dn is the marginal product of labour and $(p-cx)df/dn$ is the marginal value product of labour, and df/dl is the marginal product of land and $(p-cx)df/dl$ is the marginal value product of capital, w is the wage rate and $r(x)$ is the rent.

A zero profit condition is;

$$[p-cx]q = wn + r(x)l\tag{3.2}$$

given the output q , allows the land rent to be determined.

Under constant returns to scale

$q = (df/dn)n + df/dl)l$. therefore

$$p-cx = w/a_n(x) + r(x)/a_l(x)\tag{3.3}$$

where $a_l(x)$ and $a_n(x)$ are the output per unit factor inputs for land and labour respectively at distance x from home/road.

Solving for rx in the above equation, a bid rent is obtained. Intuitively the rent will decline as the distance from the market, home, or road to the plot increases. Since land

can be seen as a durable asset, the owner will be satisfied when she or he finds an option that will make the asset value maximum. Otherwise, the landowner could either be forced to change the activity on the land to increase return (land rent) earned in each period t , and asset value.

Intuitively, rather than leave the land idle, the farmer could opt to plant either woodlots or introduce a technology that will help the farmer to grow crops again or if it fails then he is forced to leave land idle. This raises two issues; firstly, farmers may hold on to land that is currently not close to a market or road in the hope that it soon will be profitable to use because of government investment. Secondly, farmers may still retain plots that are farther away (higher costs) because such plots are in a different topographical location that enables them to produce a particular crop that might have a higher market price p .

CHAPTER FOUR: METHODS AND PROCEDURES

4.1 Statistical and econometric analytical techniques

This section presents the analytical techniques used to achieve the objectives and test the hypotheses of the study. First, the overview of the analytical techniques used is presented. Secondly, each selected analytical technique is described and explained in detail. The following techniques were used to evaluate/test the hypotheses.

Descriptive statistics and standard deviations on selected factors are used to measure the extent of abandoned plots and to explore relationships with household factors.

An econometric technique, (multinomial logit) is used to examine the effect of plot and household and institutional variables on land use choices.

4.1.1 Bivariate and univariate analysis

The analysis was used to examine patterns of relationships between the selected households and plot level variables on land use options. Important factors that were considered included the selection of the most appropriate statistical test used to analyze these relationships. For example, the variables that were categorical, chi square test was used and for variables that were non categorical, one way or two-way analysis of variance or even a T-test was used. This was undertaken in order to examine evidence of any relationship between socio economic variables and the various land use systems.

Since the study investigated the factors related to abandonment of terraces by farmers, a wide range of farmer and plot characteristics were examined to measure their influence on the decision to abandon a given plot. These could also influence plot subjection to other forms of land use such as long fallow, woodlot and continuous cultivation. These were investigated and comparisons made between them. Household variables examined in this analysis included, number of members of household, education levels of household's head to represent management skills and age. Plot level variables such as topographic location, slope and plot fertility were also included. The results were presented in percentages and means. Before regression analysis was done, the data were examined, summarized and described to identify the primary characteristics of plots and different practices carried out on terraces to get a clear picture of the data and to

determine how best to distinguish between different levels of slope, topographical location, soil fertility, education and other categorical variables.

4.1.2 Analytical approaches to land management

Analytical models commonly used to analyze degradation, conservation and fallowing decisions that are reviewed include linear probability model, discriminant analysis, logit and probit models and finally the multinomial logit model used for this study.

The linear probability models (LPM) have been used to explain choice behaviour but have received lots of criticisms because they are plagued by several problems (Mukherjee, *et al.* 1998). These include non-normality of u_i , heteroscedasticity of u_i , generally low R^2 values and the possibility of predicted Y_i lying outside the (0-1) range. (Where u_i is the error term). It was also considered not a logically attractive model because it assumes that $P_i = E(y=1 | X_i)$, increases linearly with X_i which is unrealistic. (P_i is the probability of choice for the i th individual and $E(y=1 | X_i)$ is the conditional expectation of y , given the explanatory variable X_i (Mukherjee, *et al.* 1998).

Closely related to discrete models is discriminant analysis. If the independent variables are normally distributed, then its estimator is the true maximum likelihood estimator (Griffith *et al.*, 1993). Carveness and Kurtz, (1993) used discriminant analysis to generate an agroforestry adoption equation using data from Senegal. But, if the independent variables are not normal, the discriminant analysis estimator is not consistent (Sharma, 1996). In this study, I could not assume that independent variables are normal because the explanatory variables include both continuous and categorical variables and this violates the normality assumptions on which discriminant analysis relies.

Since the dependent variable (land use options) is categorical, the binary logit and probit techniques could work. Actually, probit was suggested as the most appropriate model to use for discrete or dichotomous dependent variable (Griffith *et al.*, 1993). However, use of probit model was rejected outright due to the underlying assumption that the distribution of the explanatory variables is normal and there is no evidence and reassuring

information. The other major limitation is that the multinomial probit is applied for only a small number of alternatives 3 or at most 4 (Maddala 1999). Since this study examines more than 4 options the computations may become impractical for probit. A popular alternative to the probit model is the binary logit model. Binary logit differs from probit model mainly in the cumulative distribution function that is used to define the choice probabilities but does not assume normality.

Furthermore, binary logit models can only be appropriate if the dependent variable takes the form of only two response levels. In this case, the response variables are more than two. Therefore the appropriate technique used was the advanced form of logit known as multinomial logit. It assumes that farmers are rational and make land use decisions that maximize perceived utility subject to constraints on expenditure. This can handle cases with more than two categories. Although the logistic regression is used, the predicted probabilities are expected to be similar to that of the probit model within the broad range of the data except on the tails (Aldrich and Nelson, 1984; Griffith *et al.*, 1993;).

The multinomial logit model has weaknesses that are not insurmountable. This model is based on the assumption that the equation models the choice behavior of the individual farmers of whether to cultivate, short fallow, long fallow, abandon or put land under woodland. The decision by the individual can be conveniently represented by the random variable that takes the value of one to five depending on the choice of the farmer. This assumes that the decision is based on the attributes of the choice, which are specific to the individual decision-maker, the individual's socio-economic characteristics and observed attributes. Hence, the model does not determine the intensity of abandonment. The model does not reveal at what stage farmers are operating. For example, plots currently in use could be on the borderline of abandonment or managed with no intention to change the land use. Furthermore, there are many errors in the optimization because of imperfect perception as well as the inability of the analyst to measure exactly all the relevant variables. In case the choices are perceived to be similar rather than independent, the model predicts too high the joint probability of selection for two alternatives. In this study, farmers perceive the choices independently.

4.1.3 The theoretical model

When terraces have different characteristics, farmers are faced with several management decisions. These include choice of land use such as annual cropping, short fallow, long fallow, abandonment and woodlot. It was assumed that the decision to abandon or put land under other land use options by a given farmer is based on utility maximization. This assumption was consistent with individual farm household behavior. The farm household can be expected to allocate labour and capital to a particular plot if that strategy yields the largest utility for the household. Other researchers have used a similar approach (Chambers and Foster, 1983; Sheferaw and Holden, 1998; Pagiola and Holden, 2001).

Following Rahm and Huffman (1984), Grisley and Mwesigwa (1995) farmers' land use decisions for the terraces based upon utility maximization can be framed as a discrete choice model. The different land use decisions are defined as j , where $j=1$ represents cropped plots, $j=2$ for short fallow, $j=3$ for long fallow, $j=4$ for abandoned plots and $j=5$ for woodlot plots. The non-observable underlying utility function that ranks the preference of the i th farmer is given by

$$U(M_{ij}, A_{ij}) \quad (4.1)$$

U is the utility derived from preference of the i th farmer

M is the vector of plot and farmer characteristics

A is the vector of attributes associated with each land use option

Thus the utility derivable from the decision to put land under one of the 5 different types depends on M which is the vector of the plot and farmer specific characteristics and A which is the vector of attributes associated with each of the land use option. Although the utility function is unobservable, the relation between the utility derived from the j^{th} land use type is postulated to be a function of the vector of observed farm, farmer specific characteristics such as farm size, plot size, distance to plot, household size, age and a disturbance term having a zero mean.

$$U_{ji} = \alpha_j F(M_i, A_i) + e_{ji} \quad j=1,2,3..5; i=1 \dots n \quad (4.2)$$

Equation (4.2) does not restrict the function F to be linear. As the utilities U_{ji} are random, the i^{th} farmer, will select the alternative $j=1$ if $U_{1i} > U_{2i}$ or if the non observable latent random variable $y^* = U_{1i} - U_{2i} > 0$. The probability that Y equals one (ie that the farmer decision is to crop or abandon) is a function of the independent variables.

$$\begin{aligned}
 P_i &= \Pr(Y_i=1) = \Pr(U_{1i} > U_{2i}) \\
 &= \Pr[\alpha_1 F_i(M_i, A_i) + e_{1i} > \alpha_2 F_i(M_i, A_i) + e_{2i}] \\
 &= \Pr[e_{1i} - e_{2i} > F_i(M_i, A_i)(\alpha_2 - \alpha_1)] \\
 &= \Pr(\mu_i > -F_i(M_i, A_i)\beta) \\
 &= F_i(X_i \beta)
 \end{aligned} \tag{4.3}$$

where X is the $n \times k$ matrix of the explanatory variables, and β is the $k \times 1$ vector of parameters to be estimated, $\Pr(\cdot)$ is the probability function, μ_i is the random error term and $F_i(X_i \beta)$ is the cumulative distribution function for μ_i evaluated at $(X_i \beta)$. The probability that the farmer will abandon a given plot is a function of the vector of explanatory variables and of unknown parameters and error term. Equation 4.3 cannot be estimated without knowing the form of F . It is the distribution of μ that determines the F distribution. If μ_i is normal, F will have a cumulative normal distribution (Rahm and Huffman 1984). Following equation (4.3), the functional form is specified with the (discrete choice model) multinomial logit model.

4.1.4 The econometric model

An econometric model of land use decisions was estimated using a snapshot data. The dependent variable (land use options) has five response levels representing the current land use option of a given terrace. These are annual cropping, abandonment, woodlot, long fallow and short fallow. The covariates include age of household head, farm size, plot distance from home /road, household size, education level, household headship, household type, plot location, soil fertility and stoniness, plot size, slope, and farmsize.

The model is presented generally as:

$$Y_i^* = \beta' X_i + \varepsilon_i \tag{4.4}$$

Where, Y_i^* is the underlying latent variable that indexes the land use option on a given plot. X_i is a $(k \times 1)$ vector of explanatory variables, β is a $(k \times 1)$ vector of the parameters to be estimated, k is the choice of the option and ε_i is the stochastic error term.

A general expression for the conditional probability for the five categories is;

$$P(Y = j) \Big| X = \frac{e^{\beta_j(X)}}{\sum_{k=0}^4 e^{\beta_k(X)}} \quad (4.5)$$

Where j is the category of land use and $\beta_j(X)$ is the logit transformation of the probability of farmers' land use option e.g abandonment and woodlot decision (Greene 2003). The probabilities for each of the observed responses, assuming we included all the 5 categories (0,1,2..4,) the model is given as

$$\begin{aligned} P(Y=0) &= P(Y_i^* \leq 0) = P(\beta_1 X' + \varepsilon_i \leq 0) = F(-\beta_1 X') \\ P(Y=1) &= F(\delta_1 - \beta_1 X') - F(-\beta_1 X') \\ P(Y=2) &= F(\delta_2 - \beta_1 X') - F(\delta_1 - \beta_1 X') \\ &\vdots \\ P(Y=4) &= 1 - F(\delta_4 - \beta_1 X') \end{aligned} \quad (4.6)$$

For example, the probability of abandonment $P(Y=1)$ is the cumulative distribution function of F evaluated at $\beta_1 X'$ where, X is the vector of all explanatory variables, β is the vector of unknown parameters, δ are the unknown parameters to be estimated with the β , and F is the cumulative distribution function (CDF) for the stochastic error term ε_i . The assumptions about the functional form of F determine whether the logit (logistic CDF), probit (standard normal CDF) is used. In our case, there is no justification for normality hence logistic is used.

4.1.5 Empirical model

The model used to estimate the influence of plot and household characteristics on land use choices is given by

$$A = \beta_0 + \beta_1 \text{ PLOROAD} + \beta_2 \text{ FARMSIZE} + \beta_3 \text{ HHSIZE} + \beta_4 \text{ TOPTOP} + \beta_5 \text{ HHPMALE} + \beta_6 \text{ SLOPMOD} + \beta_7 \text{ HHFEMALE} + \beta_8 \text{ FERTGOOD} + \beta_9 \text{ FERTMOD} + \beta_{10} \text{ EDUCPOST} + \beta_{11} \text{ STONFEW} + \beta_{12} \text{ PLOTSIZE} + \beta_{13} \text{ EDUCPRIM} + \beta_{14} \text{ TOPMID} + \beta_{15} \text{ STONMANY} + \beta_{16} \text{ SLOPSTP} + \beta_{17} \text{ AGEHH} + \beta_{18} \text{ PLODIS} + e$$

Where;

A = Land use option (cropped plots, short fallow, long fallow, abandonment and woodlots)

PLOROAD	The distance of the plot from the nearest road measured in Km
PLODIS	The distance of the plot from the home measured in Km
FARMSIZE	The total land holdings measured in hectares
HHSIZE	Number of household members measured in number of persons
AGEHH	Age of the farmer measured in years
HHPMALE	Polygamous households measured as number of women living with the head.
EDUCPRIM	Household heads with education level of primary (base case is no formal education)
EDUCPOST	Household heads with education levels of post-primary or more
HHFEMALE	Households headed by female (base case is monogamous households headed by males)
FERTMOD	Terrace plots with moderate soil fertility (base case is plots with poor soil fertility)
FERTGOOD	Terrace plots with good soil fertility
PLOTSIZE	The plot size in hectares
TOPMID	Terrace plots located in the mid slopes
TOPTOP	Terrace plots located on landscape (base case is valley bottoms)
STONFEW	Terraces with few stones (base case is plots with no stones)
STONMANY	Terraces with many stones
SLOPSTP	Steep sloped plots
SLOPMOD	Moderate sloped plots (base case is flat plots)

4.2 Examined variables and hypotheses in the land use model

Several variables were examined to determine their influence on the abandonment and long fallowing of terraces. Variables that are essentially nominal in nature such as soil fertility were entered as dummy variables (table above) to indicate the presence or absence of a quality. This helped to classify data into mutually exclusive categories such

as moderate soil fertility or good soil fertility. Thereafter the dummy variables were incorporated in the regression model just like quantitative variables such plot distance to home and age of household head.

The age of the household head was included in the model as one of the respondent characteristics to ascertain its influence on the farmers' decision to abandon or long fallow terraces. There are different relationships between the age of the farmer and the probability of plot abandonment. For example, young farmers are not expected to have accumulated many plots compared to older farmers and are therefore less likely to abandon terraces. However, older farmers are also expected to have acquired experience and resources to manage plots better than young farmers and this minimizes abandonment. In the context of Kabale, it is hypothesized that abandonment/long term fallow is likely to take place on plots for older farmers compared to young ones because they are assumed to have acquired more plots in different locations.

Social factors such as household size, gender of household head and polygamous households were also included. Household size and polygamous households were hypothesized to have a negative relationship (see Appendix 4 for signs) with abandonment whereas headship for households by female was assumed to have a positive relationship because such households may not have enough labour and ability to supervise many plots if they are scattered. The other social factor was education whose base case was lack of formal education. Educated farmers were expected to have acquired knowledge in relation to improved methods of land management. They also have the ability to acquire loans to improve the land. However, they were also more likely to divert the resources meant for soil improvement to off farm enterprises with higher returns. This therefore leads to less investment in soil improvement and increased abandonment. Therefore, a priori the hypothesized sign was unclear.

The plot related variables included in the model among others were (TOP'TOP) and (TOPMID) with plots in the valley bottom acting as a base. Topographically they are different and plots may be affected differently. As a result, they were entered separately

as dummy variables. It was assumed that plots, located on the hilltop, are more likely to be abandoned compared to plots in the valley bottom because of the distance and difficult terrain. The plots in the mid slope were hypothesized to be short fallowed because they are closer to the homes compared to plots on the hilltops and valley bottoms.

Soil fertility variation for the different plots owned by the farmer influences land use decisions. The variables (FERTMOD) and (FERTGOOD) are entered as separate variables. Plots with poor soil fertility act as base cases. It was hypothesized that soil fertility is negatively related to abandonment. Therefore, (FERTGOOD) and (FERTMOD) variables had a negative sign. The influence of plot stoniness on farmers' decision to abandon or cultivate the plots was also investigated. STONFEW and STONMANY are variables entered separately because many stones were hypothesized to encourage abandonment because it is difficult to open soil for crop production. Absence of stones is expected to encourage continuous use of the plot. Therefore, the hypothesized sign for STONMANY was positive and negative for STONFEW, but weaker.

The variables (PLOTSIZE) and (FARMSIZE) were included in the model. The hypothesized sign was positive for farmsize and negative for plot size. Due to land fragmentation, small plots are more likely to be located at some distance from homes. As a result, they are likely to be abandoned because farmers may find it less attractive to travel long distances to cultivate such small plots. Larger plots were expected to act as incentives for farmers to travel long distance and crop the plots despite the fragmentation and therefore should have a negative sign. However, if households do not have enough resources to cultivate all plots in the larger farms then the sign changes.

The variable (PLOTDIS) represented the plot distance from the home. It was hypothesized to have a positive sign. The further away the plot was from the home, the more likely to be abandoned/ long fallowed. The slope of the plot is also a characteristic expected to influence the use of the given plot. The slope variables were (SLOPMOD) and (SLOPSTP). They were entered as separate variables and flat plots are used as base

cases to verify the influence of slope on abandonment. The steeper the plot, the more difficult to cultivate, hence higher slopes are expected to have a positive sign.

4.3 Data sources and collection

This section presents the procedure for data collection of relevant information to understand the economic and institutional factors, processes and constraints that limit use of terraces. It presents the formal procedure for data sources and collection at farmer and plot level through use of survey methods. It further presents the informal procedures for data collection on the features and processes of terrace abandonment through use of institutional inquiry, secondary data and farmer meetings. Lastly, it outlines how data were processed and prepared for final analysis.

4.3.1 Research design and unit of study

The choice of design selected for this study was a combination of sample survey, rapid rural appraisal methods and secondary data. Scherr (1991) argued that a combination of informal and formal field survey methods have the advantage of obtaining qualitative and quantitative observational information and indicators. Different types of inquiries were critically evaluated before selecting the most appropriate ones to use in order to generate representative and good data.

The main unit of analysis in this study was a farmer's plot, but data were also collected on the farming household. Since factors related to terrace abandonment were being analyzed, a plot was used because it is the smallest unit of land on which cultivation takes place. However, farmers' characteristics were also critical in the analysis. As a result, household heads were used as respondents since they had a good understanding of why and what activities were carried out on these plots. During the interviews, farmers were given the opportunity to initiate and engage in feed back dialogue to create room for consistent and logical flow of information.

4.3.1.1 Population and sample size

In some situations, it is possible to obtain data from the entire population. For example, one can get data for all farmers practicing zero grazing in Kigezi since the total population could be small. However, in most cases it is impractical and uneconomical to obtain data from the whole population. Therefore, samples were taken from a representative part of the population in Kabale District in order to economize the use of resources in gathering this information.

In theoretical terms, the sample size required for the survey depended upon three factors (Poate and Daplyn, 1993); a) the level of precision required in the estimates- implying that the greater the precision the larger the sample size. b) The variance of the variables being estimated- implying the greater the variability the larger the sample size required for a given level of precision. c) The sample design being used- suggesting that a stratified design used tends to reduce the sample size required for a given level of precision and clustered design will tend to increase it. In this research, we sought to have the following outcomes:

First, an adequate sample size to make valid statistical inferences about the total population with the desired degree of confidence was obtained. Second, a sample with a fair and representative number of farmers and plots, farm size and tenure was obtained so that the groups fairly represent the whole population using stratification.

Poate and Daplyn (1993) provided a good formula for calculating the sample sizes when interested in precision about a statistic for sample proportions. However, in analyzing abandonment, it was not a good a guide in order to get the right sample size for use in regression analysis (Balcombe, 2000). He argued that the classical approach to determine the sample sizes gives a margin of error with an acceptable degree of probability. However, in practice this is not the case as a wide range of variables of interest such as land size, tenure have differing variances. As a result, the strategy taken in this study was partly to consider practical considerations and collect information from as many farmers as resources could allow for use in the analysis of abandonment.

Other important criteria were to have a good number of plots in the different land uses. For example, if one expected to find about 5% of plots to be abandoned, and it was deemed useful to have at least 100 observations, then 2000 plots would need to be sampled. Since households are known to have 6- 10 plots on average, a sample of over 300 would be appropriate. Therefore, the sample size was determined based on the representation of the system and the practical consideration of data collection within limits of available resources. Nevertheless, the rules and guidelines for selecting farmers to interview still hold as the sampling frame is presented.

4.3.2 Sample frame and farmer selection

Planning for a farm survey involves dividing the population into parts that are called sampling units. These units must cover the whole of this population of interest. In this study, data were taken from all the three counties. Kabale district has three counties and a total of 19 sub counties. In each county, two sub counties were selected. In total, six sub counties were visited. These included Kashambya, Kamwezi, Rubaya, Maziba, Bubale and Hamurwa sub counties. The sampling frame in this study was based on administrative units firstly selecting counties, sub-counties, and then parishes. Within parishes, a complete list of all farming households in the locality was drawn. The lists of all households or dwellings in the parish were used for selecting farmers for interview. After obtaining a reliable sampling frame, building the sampling procedure involved avoiding bias in the selection process and achieving maximum precision for the outlay of resources. This bias was avoided by taking a random sample by using a table of random numbers as below:

Table 4.1: Type and number of selected administrative areas in Kabale District and sampling methods used

Administrative unit and corresponding numbers surveyed		Method used and number of people interviewed	
Administrative unit	Number surveyed	Method Used	Number Interviewed
County	3	Purposive sampling	120
Sub-county	6	Simple random	60
Parish	18	Simple random	20
Village	36	Simple random	10

In order to allow for a wider coverage and collect data from a representative sample, the respondents were selected and interviewed at random. Selection of sub-counties and parishes was done by use of multistage simple random sampling. Twenty farmers were chosen from each parish giving a total of 60 farmers for each sub county. Given the resources available the interview was carried out in 18 parishes. Data were collected from a total sample of about 360 households. Given the number of plots per household in the district, 2,550 plots were covered in the survey. Two visits to the study areas were made. One comprised of the pilot survey and another was to collect field data (Appendix 6a).

4.3.2.1 Pilot survey

The purpose of conducting the pilot survey was to collect information on the various aspects of abandoned terraces. It was also used to develop a fieldwork procedure, test the questionnaire and train the enumerators on how to gather relevant information in the specified time. Pilot survey also helped understand farmers' perceptions on fallow and abandonment. The differences between fallow periods in the past and as currently perceived were established. The difference between seasonal, long fallow and abandonment were described. A pilot survey was carried out in Rukiga, Ndorwa and Rubanda counties of Kabale District. This involved visiting farmer groups, opinion leaders and elders to establish their perception of the different uses of the plot.

The pilot survey also involved drawing lists of sub-counties, parishes, and households to help identify areas for the formal survey. Information of broad nature was collected at household level. It consisted mainly of whether abandoned terraces are common, the causes and where they are common, number of plots owned, location and distance from the road, nearest market and other factors related to management and constraints. These helped to redefine the questionnaire before final interview with farmers. It also assisted to crosscheck the sampling frame and make necessary adjustments.

4.3.2.2 Questionnaire design

In order to obtain comparable and generalizable results, the questionnaire was standardized for all localities in order to collect uniform information. The questionnaire

contained some qualitative variables, quantitative variables and few open-ended questions (See Appendix 6b). The questions were related to the characterization of the farmer, household, the plot and current management of terraces and related constraints. Questions were short and in tabular form for easy entry. Again, they were specific but some allowed farmers to express their opinion based on experience and knowledge. The questionnaire was pre-tested for relevance, sequence of questions as well as time during the pilot survey. The weaknesses and problems of the questionnaire set up were clarified and corrected. Questions though written in English were asked in vernacular (Rukiga). For ease of data entry into the computer, questions were coded.

4.3.2.3 Methods for data collection and entry

Data collection methods mainly included individual farmer interviews by use of a questionnaire (Appendix 6). In order to reduce potential inaccuracies, the choice of respondents was made randomly; the timing and circumstance of the interview, the structure and the content of the interview were carefully chosen. To minimize other non-sampling errors, the researcher with the support of two field technicians carried out the interviews. Prior to the survey, training was arranged to familiarize the enumerator with the questionnaire and approaches to interviews. Since there were no records expected on farms, farmers gave answers based on memory recall. The household head/spouse was interviewed through face-to-face interview. Before the interview, each farmer was briefed about the data being collected. It was made clear that the information was for study purposes and had nothing to do with taxation. Twenty weeks were spent for the survey

The purpose of the formal survey was to collect data from relatively representative sample of farmers in order to investigate and test our proposed objectives and hypotheses. The specific plot data of interest collected included socio-economic and biophysical variables that influenced farmers' management of plots. Few important socio-economic ones include age, presence of markets, labor and education. Distance to plots from home, soil fertility and topographic location are some of the important biophysical factors. The survey was carried out on farmers' plots after identifying locational areas of research and

corresponding households. Since the unit of analysis was a plot, visits to some of the farmers' plots for visual comparison of terraces were made.

Other data required included; ownership of the land to be established, the size, niches and distance of fields from the homes were determined. Formal field survey generated specific information that helped to understand the differences within plots and household categories. Table 4.2 presents the summary of the data collected in the study in the general context of socio economic, biophysical and institutional setting of farmers.

Table 4.2: Forms of data collected

Socio-economic	Biophysical factors	Institutional factors
Age of household head	Soil fertility	Links to extension
Presence of markets	Current status	Links to research
Capital	Crops grown	
Farm size	Topographic position	
Labor	Slope	
Education	Distance to plot	

After data were collected, they were coded, cleaned and entered using SPSS program. These data were categorized into discrete and continuous variables since analytical methods used (as described before in the chapter) are capable of handling both types of data. SPSS and STATA computer programs were used to analyze the data.

4.3.2.4 Farmer feedback meetings

This participatory technique was used to get a general understanding of the factors that influence the different land uses and constraints that limit better use of terraces. It was also used to crosscheck and confirm the reliability of the information collected and highlighted areas of ambiguity in the questions and recording. After the data were analyzed, research findings were presented to farmers and policy makers to get feedback. Two meetings were organized one at county level and another at district level to involve as many opinion leaders, farmers and policy makers as possible.

In order to determine the major constraints that limit implementation of the by-laws and evaluate policy options, innovation and incentives that increase economic output from abandoned terraces, two workshops were organized. one at the sub county and one at the

district. Major findings from the survey were presented and issues arose from the presentation. These included characteristics of long fallows and abandoned terraces, reasons why they are not cultivated, possible solution, what can be done to these challenges. District councilors were invited to devise strategies for overcoming the problem of long fallows and abandonment in Kabale district. The output at the district mainly looked at the proposed interventions for the different land use options, proposed strategy, and appropriate mechanism that could be put in place to improve output from abandoned terraces.

The major objectives were threefold:

Firstly, to describe and analyze fully the possible set of problems, underlying causes and constraints related to the abandoned terraces and long fallows and develop suggestions on how to improve the management of these terraces. This partly helped to explain the statistical and econometric results and generated ways to solve some of the problems.

Second, to promote farmer discussion and prioritization of the causes of abandonment and long fallow. Farmers identified those that could be dealt with using available technologies and those that required further research and policy interventions. Thirdly, to evaluate farmers' willingness and commitment to solve the identified problems and implement perceived solutions.

Farmers and opinion leaders in Kabale District are expected to know the causes of different types of fallows and abandonment and to distinguish between them. First they had to distinguish between the different types of long fallows based on the characteristics given by the survey results. This exercise was done in two groups per sub-county. Men and women were put in different groups and later they would go for plenary. Farmers were asked to rank the causes of a plot being subjected to a particular land use type. Farmers ranked all causes using a Likert scale of 1-10 to determine which of the causes was responsible for a particular land use type. After scoring each cause according to farmers' perception, the scores were added to obtain the total score and divided by the number of farmers to obtain the average. With the total and average score the single greatest cause of each of the different types of long fallows and abandoned terraces was assessed according to the farmers' perception.

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Introduction

Results are presented as follows; firstly, the extent of land abandonment and long fallows with associated causes. Secondly, land use categories in relation to selected household and plot variables are also examined through use of ANOVA. Thirdly, multinomial logit regression estimates for selected variables that influence land use options are estimated and presented. Fourthly, types of long fallows and abandonment are identified and the distance from home variable is used to examine further the differences between cultivable long fallows and abandoned terraces.

5.1.1 Nature and extent of abandonment

The common land use options as revealed by farmers comprise mainly of land under continuous cultivation, short fallow, long fallow, abandoned plots and woodlots (figure 5.1). The current use of terraces by farmers revealed that about 60% of the total plots surveyed in Kabale District are continually cultivated with crops.

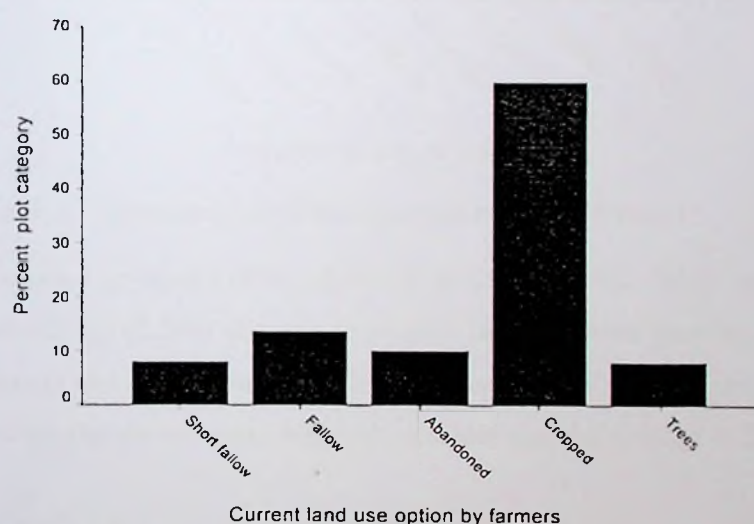


Figure 5.1: The land use categories in Kigezi highlands

The short fallow and long fallow comprise of 8% and 14% respectively. Farmers abandon about 10% of the plots surveyed. Terraces occupied by woodlots comprise about 8% of

the total plots visited. The total uncultivated area that comprise of short fallow, long fallow and abandoned terraces is over 30% of the entire area surveyed.

5.1.2 Farmers' reasons for fallowing and abandonment

Results revealed that poor yields are the main cause of long fallow and abandonment of fields. However, close examination of data shows that soil fertility is not the only problem that affects crop yields (Figure 5.2). The other characteristics that contribute to poor yields and abandonment are discussed later in section 5.6.

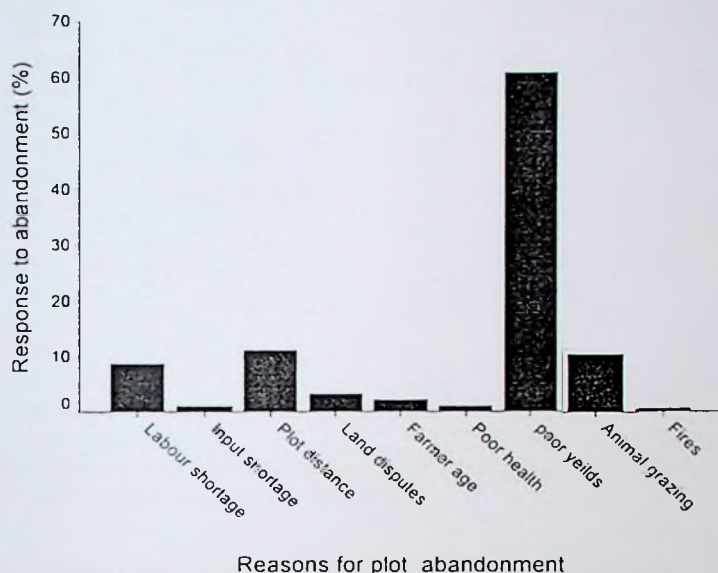


Figure 5.2: Reasons for land abandonment in Kabale District

Livestock grazing (10%), distance to fields (11%), labor shortage by households (9%) and old age (2.3%) are also important factors. Other reasons such as fires, poor health of farmers and lack of inputs influenced use of about 3% of the terraces surveyed. The next section reports on some selected variables and the linkage to land use options.

5.1.3 Variations in selected variables that influence land use decisions.

Results revealed that the average distance of plots from the home and the nearest road is about 1.15 km and 1.5 km respectively. The distance ranged from 0 to 20 km from the home and road. In Kabale District, even when distances are less, the terrain makes it difficult to reach these plots that appear to be near homes. (As a result, later in section

5.5.1, the distance variable is used to distinguish between long fallows and abandoned terraces). The mean distance to the market from plots is 6 km. The average number of plots owned by the household is 8 plots. They range from 1 to 20 plots per household although these plots are usually scattered over the landscape. Having several plots located on different parts of the landscape is common and is used as a risk management strategy although it could lead to sub optimal use of terraces.

Table 5.1: Variations in factors that influence farmers' land use decisions.

Factors	N*	Minimum	Maximum	Mean	± S.E
Distance of plot from home	2530	0.00	20.00	01.15	0.03
Distance of plot from road	2530	0.00	15.30	01.47	0.04
Distance of plot from market	2530	0.00	35.00	06.06	0.01
Total number of plots	2530	1.00	20.00	07.80	0.08
Farm size	2530	0.07	46.00	10.97	0.25
Age of household head	0360	18.0	82.00	45.12	0.27
Household size	0360	1.00	23.00	07.73	0.00
Number of cattle/ household	0360	0.00	58.00	02.19	0.09
Size of plot	2530	0.03	25.00	01.26	0.04
Area under wood	2530	0.00	27.00	00.98	0.148
Area under short fallow	2530	0.00	25.00	00.68	0.119
Area under fallow	2530	0.00	26.00	01.23	0.149
Area under abandoned	2530	0.00	57.00	01.07	0.193
Area under floods	2530	0.00	05.00	00.25	0.014
Area under crops	2530	0.00	60.00	04.88	0.014

Note: Distance was measured in km, farm size and area was in acres:

N* 2530 for plots and 360 for households

The mean farm size is 4 ha but this appears to be high relative to existing data. However, when data are examined further to the extent that the extreme values or outliers (e.g farmers with over 16 ha) are excluded from the analysis, results still revealed that farmers have about 2.14 ha of land. A cross-examination of results suggested that the estimate of land holding of less than 1 ha per farmer in Kabale district could be an underestimate by not taking into account of all the land farmers own on the hillsides. Alternatively, it could be argued that since every farmer's plots were not visited and measured accurately, there is a chance that an average of about 3–4 ha per farmer could be an overestimate. Therefore, the methodology that incorporates all the land on the hillsides gave a better estimate.

5.1.4 Land use options in various counties

In Rukiga, 14% of the plots surveyed are under short fallow. Ndorwa and Rubanda counties had 6% and 3% of plots under short fallow respectively. In Ndorwa and Rukiga counties have 15% of plots under long fallow. The results also revealed that across the 3 counties about 8% of the plots were abandoned.

Table 5.2: Land use of terraces in various sub counties

County	Short Fallow (%)		Long Fallow (%)		Abandoned (%)		Woodlot %		Cropped (%)		Total plots (%)	
Rukiga	14		15.5		8.1		10.7		51.6		972	100
Ndorwa	6.2		15.2		7.8		11.2		59.7		769	100
Rubanda	2.6		10.4		8.4		8.5		70.1		789	100
Total	205	8.1	347	13.9	205	10.2	257	10.2	1514	67.8	2530	100

Number of farmers=360; number of plots= 2530, Sig. 0.000

Seventy percent of plots in Rubanda, and 60% in Ndorwa counties are cropped compared to only 52% in Rukiga that had the fewest cropped terraces. There was less long fallowing (10%) and fewer woodlots (8.5%) than in Rubanda and Ndorwa counties.

In order to understand what proportion of farmers had at least one of their fields under long fallow and abandonment, the land use options were examined in relation to households. Thirty percent and 48% of farmers had at least one plot under short and long fallow respectively.

Table 5.3: Households and land use categories

	Short fallow	Long Fallow	Abandoned	Woodlot	Cropped	Total
No of Farmers	99	163	150	139	257	360
%	30.3	48.1	41.7	38.6	99.2	100

About 42% of farmers had at least one abandoned plot while 39% had woodlot. About 99% of farmers had at least one cropped plot. Arguably, 40 to 48% of farmers with one plot or more under either long fallows or abandoned is high in the area that is expected to be intensively cultivated all the year. Furthermore, land is the major source of both income and food for all households.

5.2 Plot and social-economic characteristics and land use options

The importance of plot characteristics as major determinants for land use systems has been highlighted in many biophysical studies (Kakuru, (1994), Raussen *et al.*, (2000). The important variables that were examined here included, plot visibility, topographic location, soil fertility and steepness of the terraces. The importance of some of these and more variables was examined further using both multinomial logit. This section analyses the variables using cross tabulations and reports the significance using the chi square test.

5.2.1 Plot visibility and current land use

A priori, it is hypothesized that the visibility of the plot from home could influence their use and management. Results revealed a significant difference in plot visibility in relation to different land use systems. The analysis of the overall distribution of plots by visibility revealed that (39%) of the plots surveyed were visible from the homes. Only 28% and 24% of plots that are under short fallow and long fallow were visible from the home respectively.

Table 5.4: Plot visibility from home and land use systems

Visibility	Short Fallow %	Long Fallow %	Abandoned %	Woodlot %	Cropped %	Total %
No	72	76	56	75	54	1543 61
Yes	28	24	44	25	46	987 39
Total	205 00	347 100	205 100	257 100	1514 100	2530 00
Chi square: 99.218 Significance level: 0.000						

However, (46%) and (44%) of the cropped and abandoned plots were visible from the home respectively. Contrary to expectation abandoned terraces were relatively more visible from home compared to short and long fallow. The cropped and abandoned plots were also more than one and a half times more visible from home than plots under other land use systems.

5.2.2 Topographic location of the terrace and current use

For each of the plots owned or operated by the respondents, information on location on the landscape, slope, distance to the farmers residence, size, how it was acquired and

farmers subjective ranking of the quality of land in terms of soil fertility and local soil classification are examined. Using cross tabulations, the chi square test revealed a significant difference between topographic location and the land use options.

Table 5.5: Location of the plot and current use

Topographic	Short Fallow%	Long Fallow %	Abandoned %	Cropped %	Woodlot %	Total %
Hilltop	12.2	22	17.1	43.1	5.8	434 100
Mid slope	5.6	11	10.8	62.6	10	1609 100
Valley bottom	12.3	15.3	4.6	64.1	3.8	504 100
Chi square value: 148.999; Significance. 0.000						

The analyses revealed that 12% of hilltop plots are under short fallow compared to 17% that are abandoned. However, 22% of the plots on the hilltop are under long fallow. On the hilltops, (43%) plots are cropped compared to (6%), that are under woodlots. Five percent of the plots in the valley bottom are abandoned compared to 15% that are under long fallow. Eleven percent and 10% of the mid slopes are under abandonment and woodlots respectively compared to 6% that are under short fallows.

5.2.3. Farmers' evaluation of soil fertility for the land use options

Farmers ranked soil fertility of the plot based on their subjective evaluation criteria. Chi square test was highly significant at 1% level. Forty percent of the short fallow plots are on fertile and moderately fertile plots respectively compared to 21% on poor soils. About 66% and 65% of plots that are either abandoned or under woodlots are on poor soils compared to 23% and 18% of abandoned and woodlot plots on moderate soils. However, (22%) of plots under long fallow and abandonment (11%) are on fertile soils while 50% of long fallow plots and (66%) of abandoned plots are on poor plots.

Table 5.6: Farmers rating of soil fertility of the plot and current use

Soil fertility	Short Fallow %	Long Fallow %	Abandoned %	Cropped %	Woodlot %	Total %
Fertile	39.5	21.8	10.7	53.6	17.5	1035 40.9
Moderate	40	28.1	23.4	35.3	17.5	807 31.9
Poor	20.5	50.1	65.9	11.2	65	688 27.2
	100	100	100	100	100	2530 100
Chi square value 664.85 significance 0.000						

Results, revealed that (54%) and (35%) of cropped plots are respectively on fertile soils and moderate soils. Only 11% cropped plots are on poor soils. Furthermore, farmers prefer to put woodlots (65%) on the poor soils compared to either fertile soils or moderate soils with (17.5%) woodlots respectively. This implies that farmers prefer to use most plots for agricultural production and other productive activities like woodlots rather than leaving it idle. Long fallow and abandonment are less practiced on moderate and fertile soils.

5.2.4 Farmers rating of slope/ gradient of the land use options

The slope of the given plot appeared to influence the plot use for agricultural production as it affects soil and water movement. The results that compared the slope of the plot with the land use system revealed that short fallows are common on plots located on gentle slopes (62%) compared to (24%) and (15%) on moderate and steep slopes respectively. Contrary to expectation (52%) of long fallow plots are on gentle plots and least common on the steep slopes (20%). However, for abandoned plots (31%) and (42%) are most common on gentle and steep slopes respectively. The chi square test is highly significant at 1% level.

Table 5.7: Farmers rating of slope/ gradient of the plot and current use

Plot Gradient	Short Fallow %	Long Fallow %	Abandoned %	Cropped %	Woodlot %	Total	%
Gentle	61.5	51.9	31.2	51.7	35.8	1246	49.2
Moderate	23.9	28.1	26.8	35	39.7	834	33
Steep	14.6	20.1	42	11.3	24.5	450	17.8
Total	100	100	100	100	100	2530	100

Chi square value 140.27 significance 0.000

Majority of cropped plots are located on gentle slopes (52%) followed by moderate slopes (35%). Very few cropped plots are located on the steep slopes (11%). The higher percentage of cropped plots on gentle slopes could suggest that soils on gentle gradient are more likely to be under better management compared to plots on steeper slopes. The presence of cropped plots on the moderate and steep slopes suggested that farmers are willing to grow crops if technologies are available to allow the practice on such plots.

The presence of abandoned plots (42%) and woodlots (24%) on steep slopes further revealed that farmers are limited in their access to given inputs and other related factors. Based on the results above, the moderate slopes appear to require urgent attention as a small fraction of the land use system (39%) is under crop production.

5.2.5 Socio-economic characteristics and land use options

Some authors have highlighted the importance of socio-economic characteristics in influencing farmers' behavior and attitudes towards management of soil conservation and land management (Pender and Duron, 1998; Pattanayak and Mercer, 1998). Understanding farmers' characteristics can help to distinguish factors that influence farmers' decision. This part of the study sought to ascertain whether there are socio economic characteristics that influence farmers' land use decisions. The findings from the analyses revealed certain categories of people being more inclined to use terraces in a particular manner than do others. Alternatively, researchers could tailor their technologies for different land use systems and terraces to prospective policy makers and farmers based on the findings. Therefore, a wider range of socio and economic characteristics were compared for farmers with different activities on terraces.

5.2.6 Marital status

Marital status in peasant economy is important because it was assumed that women are a major source of family labor. Women contribute to the farm supply and provide financial support to the household. In addition, women are actively involved in planting, processing and marketing of produce. There is likely to be a positive benefit resulting from these complementary roles of husband and wives with both male and female heads more capable of utilizing all the fields. In polygamous households, fields were surveyed under one household head.

Table 5.8: The number of wives with household head and land use options

No of wives	Short Fallow (%)	Long Fallow (%)	Abandoned (%)	Woodlot (%)	Cropped %	Total
1	8.1	12.8	8.3	10.6	60.2	2284 100
>2	8.1	23.2	6.1	6.1	56.5	246 100

Chi square value: 22.94, Significance: 0.000

Majority of households interviewed were married with their wives resident within the household. A Chi-square test statistics revealed a significant difference for the different samples at 1% level. Among the plots owned by farmers with one wife, 8% of plots are abandoned compared to 6% of plots owned by farmers with more than one resident wife. However, fewer plots (56.5%) for households with more than one resident wife are cropped compared to households with one resident wife (60%). More plots (23%) owned by households with more than one wife are under long fallow compared to (12%) for households with one resident wife. There is no clear explanation for this occurrence. It is possible that for wealthier households, women could be a source of cheap labor. This implies that men who have more than one wife could have more plots of land compared to those with one. However, (11%) of plots owned by farmers with one resident wife are under woodlots compared to 6% of plots owned by farmers with more than one.

5.2.7 Level of education

The level of education an individual attained could exert a great influence on his farm management decisions. Education is important because understanding recommendations and soil improvement techniques could be enhanced. Again, educational attainments influence the range of choices open to farmers especially off-farm employment and part time farming. For example, in order to obtain loans from the banking sector, applicants cannot avoid filling forms of application. This by implication means that illiterate farmers could find it difficult to obtain loans and improve agriculture on their farms. Again, education enhances ability to acquire and process information officially and allows a farmer to produce more output from a given bundle of inputs. Therefore, higher levels of education could be associated with higher input and less abandoned and long fallow fields. However, it could further be interpreted that more educated people have more off-farm interests and therefore do less crop farming.

Table 5.9: Education for the household head and land use systems

Education	Short Fallow (%)	Long Fallow (%)	Abandoned (%)	Woodlot (%)	Cropped (%)	Total	(%)
None	6	18.2	6.4	10.2	59.1	450	100
Primary	6.9	13	8.6	9.2	62.2	1382	100
>Primary	11.7	12.5	8.2	12	55.6	698	100

Chi square value: 31.650; Significance: 0.000

In this study, three levels of education are identified ranging from no formal education to attendance of tertiary institutions. The hypothesis to test was that the level of education did not significantly influence the various land use options. The test statistic revealed a significant difference between the samples at 1% level of significance. Eight percent of plots owned by farmers with post primary education are abandoned while 6.4% and 8.6% are respectively abandoned for farmers with no formal education and primary education. However, (12%) of plots owned by farmers with higher education are under short fallow compared to (6%) of the plots owned by farmers with no education. In addition, (18%) of plots owned by farmers who had no formal education are under long fallow compared to (13%) of plots owned by farmers with higher education. This was consistent with the hypothesis that farmers with no formal education are expected to have fewer resources. They are also less able to acquire knowledge to improve their plots compared to those with primary education.

Furthermore, there appeared to be a major difference between plots owned by farmers with no formal education that are under short fallow (6%) compared to those under long fallows (18%). Of the plots that are owned by farmers who had attained primary education, (7%) were under short fallow compared to (13%) that are under long fallows.

5.2.8 Land ownership, farm size and land use systems

The two predominant methods of acquiring land in Uganda are by inheritance and personal purchase. About 43% of the land was acquired through inheritance while 52% of the land was got through land purchase. Other forms included renting (1%) and free acquisition (3.4%) from relatives and friends. The total land the farmer has access to include the land that he currently cultivates and the land that may be either rented or

given to others for use. Land is quite often used as a measure for wealth and appreciates over time.

Consequently, it can be hypothesized that farmers with greater access to land can bear higher risks and would be willing to invest in land improvement techniques. Additional land could permit cultivation of plots at various locations on different kinds of soils and under different climatic conditions. Land could also be held for non-productive purposes implying a positive relationship. The hypothesis tested was that there is no significant difference in land holdings between farmers with different land use systems. The statistical test of significance on the farm size in relation to land use options was significant at 1%. The test therefore rejects the null hypotheses that average size of land could partly influence farmers' decision to put land under different enterprises.

Table 5.10: The total farm size and land use systems

Farm size (acres)	Short Fallow (%)	Long Fallow (%)	Abandoned (%)	Woodlot (%)	Cropped (%)	Total	
0-5	6.3	11.3	6	10.9	65.5	965	100
5.1-10	7.0	15.3	9.4	10.2	58.1	688	100
>10.1	10.9	15.4	9.4	9.4	55	877	100

Chi square value: 25.25; significance: 0.000

Land holdings are based on the total area owned by the head of the household in acres. Farmers with 5 acres of land or less had (11%) of their plots under long fallow compared to (15%) for farmers with more than 10 acres. About (6%) of plots owned by farmers' with 5 acres or less are abandoned compared to only (9%) of the plots owned by farmers with more than 10 acres. Of the plots owned by farmers with 5 acres of land or less (65%) are cropped compared to 55% for farmers with more than 10 acres. Furthermore, farmers with 5 acres or less have 6% of their land under short fallow compared to 11% under long fallow while richer farmers had 11% of their land under short fallow and 15% under long fallow.

5.3 Analysis of variance for selected variables

Analysis of variance was used to test the hypothesis that the various means are equal. In addition it was also used to test which means were significantly different from each other.

A relationship of the sum of squares was summarized in the ANOVA Tables (Appendix 7) for selected variables. Inferences about the effect of age of household head, plot size, farm size, plot distance from home and market based on F tests and P values were obtained from the tables by testing the following null hypotheses

The effect of each dependent variable does not exist for the different options

The interaction effect of dependent variables among the specific options is zero

The mean differences for between and within groups for selected variables for the land use options are given using empirical data. Plot distance to homes varied significantly with land use options ($F_{4, 2371} = 35.66, p < 0.000$) (one way ANOVA). Comparison of distance of plot from home by land use options reveals high significant levels for all interactions. Additional tests for comparison of plot distances to home with the specific land use options revealed that plot distances between long fallows and short fallow vary significantly. Furthermore, plot distance from home for comparisons between abandoned and long fallows, woodlot and abandoned plots are highly significant ($p < 0.001$). This implies that farmers' decision to put land to a specific land use is based on distance.

The mean differences between and within groups for plot distance from road vary significantly with land use ($F_{4, 2371} = 6.04, p < 0.000$) (one way ANOVA). Comparison of distance of plot from road by land use options revealed high significance levels for most interactions. Additional tests for comparison of plot distances to road with the specific land use options revealed that plot distances between abandoned and long fallows, woodlot and abandoned plots were highly significant ($p < 0.001$). Since the P values of these F statistics were highly significant, the hypothesis that coefficients for distance of plots from home and road are equal to zero is rejected. It was concluded with greater confidence that plot distance to home and roads influence farmers' land use decisions.

A relationship of the sum of squares for selected variables for household variables included age of the household head, farm size, and polygamous households based on F tests and P values. The F values in relation to P values for households variables are highly significant for farm sizes and polygamous households ($F_{4, 2371} = 10.64, p < 0.000$)

(one way ANOVA), and ($F_{4, 2371} = 6.13, p < 0.000$) (one way ANOVA) respectively. Age of the household head ($F = 2.14$) was significant at 10%. The implication from this is that farmers' decision to put land to a specific land use could also be based on household variables. The above analysis suggests that plot distance to homes, plot distance to roads and market, and have a significant association with the farmer's land use decisions.

5.4 Land use models

In order to generate linear unbiased estimators, model-building processes was approached as follows. Multicollinearity was checked using pairwise correlation among variables. The pairwise correlation coefficient between two regressors was low (< 0.4) which indicated that data had no multicollinearity problem. Heteroscedasticity was detected using both informal and formal methods. For example, the nature of the variables suggested the presence of heteroscedasticity. Since the cross sectional data involved large and small farmers sampled together, a high likelihood of heteroscedasticity is expected in the error variance. Initially, a large sample size that comprised over 2500 field plots had been used to minimize errors due to differences in variances. During analysis, outliers were identified and omitted from the data set before variables were entered for model building. However, further analysis of variance confirmed the presence of heteroscedasticity. As a result a robust approach with STATA was employed (Hamilton L.C 2003).

This approach helped to accommodate heteroscedasticity of unknown a priori form (White 1980, Greene 2003) and adjusts standard errors. It allowed for a robust estimation in cases where multi stage sampling sample designs are used (Deaton 1997, Ersado *et al.* 2003) which was the case with our sample. Robust regression approach aimed at achieving almost the efficiency of OLS with the ideal data and substantially better than OLS efficiency in non-ideal, non-normal errors situations like we faced with our data. Robust regressions resist the pull of outliers by giving better than OLS efficiency in the face of non-normal heavy tailed error distributions. The approach produces heteroscedasticity in corrected variances and standard errors.

5.4.1 Appropriateness of the equation for the land use model

The quality of the model in appropriately fitting the data is assessed using the classification table (Appendix 8) and the goodness of fit produced by the model (Appendix 9). Comparing the predicted results of the model to the expected outcomes assesses the quality of the model. The results revealed that the model correctly predicted 34% of plots under woodlots, 21% of plots under long fallows, 25% of plots under abandonment and 92% of the plots under cropping. About 64% of the total number of plots is correctly predicted. The overall satisfactory percentage of correct prediction confirmed the quality of the estimates. It further proved their reliability to estimate the probability that given the farmer and plot characteristics, the farmer will adopt a given land use option for a particular plot.

The goodness of fit estimates was used to examine the quality of the model. It compared the likelihood of the observed results given the parameter estimates obtained by the model when only one constant term is used with the estimates and all the independent variables are included. The goodness of fit tested the hypothesis that the coefficients for all the terms in the model except the constant term are zero. The test is carried out using the log likelihood estimate. The chi square value was 999.492, which is significant at 1% level. This implied that the null hypothesis was rejected as the included parameter estimates are significantly different from zero and can be relied upon to estimate the probability that the plot is likely to fall in each of the five land use categories.

5.4.2 Model estimation and analysis

Multinomial logit regression analysis was used to test the hypothesized relationships in case the dependent variable took on one of the five outcomes. The land use options were cropping cultivation, short fallow, long fallow, woodlots and abandonment. The base case against which the probabilities were compared was crop cultivation. Both household and plot characteristics were found to influence farmers' decision to put land under different land use options. However, the results suggest that plot variables are critical determinants in influencing farmer's decisions to abandon land or put it under long fallow compared to household characteristics. The estimates of the determinants of

farmers' decisions for each separate category are presented in Tables 5.11 and 5.12. Table 5.11 presents results for short and long fallow model while Table 5.12 presents woodlot and abandonment model results respectively.

Results revealed that five variables were significant for short fallow, four variables for long fallow, four variables for woodlot and seven variables for abandoned terraces at 1% level of significance. However, at 5% level of significance, two additional variables were significant for short fallow, three additional variables for long fallow, one additional variable for woodlot and three additional variables for abandoned terraces. This partly distinguishes abandoned terraces from other land uses based on the significance of the variables.

The coefficients in Tables 5.11 and 5.12 can be interpreted as the change in the log odds associated with a unit change in the respective independent variable. They represent the factors by which the plots take up a specific land use relative to being under cultivation (odds) when the included independent variables change by one unit. As mentioned before the signs could either be positive or negative. A positive sign coefficient implies that the odds are increasing and a negative sign implies that the odds are decreasing. Technically, the coefficients can be presented either as log odds or simply as odds ratio. The odds ratio was calculated using the formula e^{β} that is, (exponentiation of the slope coefficients). In this study, the coefficients are presented and interpreted as odds ratios.

5.4.3 Short and long fallow model

This sub-section present results of land use decision models in the following order. Firstly, short fallow model, long fallow, woodlot and abandonment models were presented respectively. The variables that are significant for short fallow model included PLOTSIZE, FARMSIZE, EDUCPRIM, EDUCPOST, PLOTMID, FERTMOD, FERTGOOD and PLOTDIS. The short fallow model results show that the odds ratio values for a given plot to be under short fallow were significant for household variables namely (EDUCPOST and FARMSIZE) at 1 % level of significance. For example, the odds ratio values obtained for EDUCPOST was 2.260. This implied that as the variable

changes from no formal education to EDUCPOST, the odds ratio for the plot to change from cultivated plot to be under short fallow increases compared to that of no formal education, the value of other independent variables are held constant.

Table 5.11: Estimated coefficients and odds ratio for factors influencing farmers' decisions to either use land for short fallow or long fallow.

Factor	Short Fallow		Long Fallow		
	Coefficient	estimate	Odds ratio	Coefficient	estimate
	of the hh/plot factor			of the hh/plot factor	
					Odds ratio
Intercept	-1.799			-0.767	
AGEHH	0.003	1.002		0.013	1.013**
HHSIZE	0.003	1.003		-0.059	1.060
EDUCPRIM	0.118	1.125		0.217	1.240
EDUCPOST	0.816	2.260***		-0.013	1.014
HHFEMALE	0.105	1.110		0.488	1.630**
HHPMALE	0.026	1.027		0.445	1.550**
TOPTOP	0.299	1.348		0.279	1.321
TOPMID	-0.723	2.060***		-0.526	1.692***
FERTMOD	-0.486	1.625**		-1.657	5.243***
FERTGOOD	-0.877	2.403***		-2.276	9.738***
STONFEW	-0.230	1.258		-0.172	1.188
STONMANY	-0.359	1.431		0.031	1.031
PLOTSIZE	-0.133	1.142**		-0.017	1.017
SLOPMOD	0.086	1.090		0.225	1.250
SLOPSTP	0.297	1.346		0.294	1.341***
PLOTDIS	0.126	1.134***		0.195	1.215
FARMSIZE	0.026	1.026***		0.005	1.006

*, **, *** denotes statistical significance at the 10%, 5% and 1% level respectively

hh denotes household. Analysis was done using multinomial logit function against abandonment, woodlot, short fallow and long fallow based on continuous cultivation.

Plot variables such as TOPMID, PLOTDIS, FERTGOOD significantly influence short fallowing at 1% level of significance. For example, the results showed that the odd ratio of TOPMID is 2.060 and has a negative sign. This implies that the probability of a plot being under short fallow was about 2 times less likely if it was located in the midslopes relative to the plots in the valley bottom. Other variables such as (PLOTSIZE) and (FERTMOD) were significant at 5% level and had the hypothesized signs. Furthermore, the negative sign on plot size in the short fallowing decision suggested that the bigger the plots, the less likely it is to be put under short fallow as opposed to being cultivated. The smaller the plot, the more likely it is to be short fallowed. In general, variables related to the plot appear not to exert strong influence on plot being subjected to short fallow.

Three variables related to personal characteristics were significant at 5% level. These include the age of the household head (AGEHH), households headed by females (HHFEMALE) and polygamous households (HHPMALE). Relationships of long fallow to age of household head had a positive sign. This implies that long fallow plots were more likely to occur with older farmers compared to younger ones. The (HHFEMALE) variable was another household variable that was highly significant with odds ratio values of 1.6. This shows that the probability (odds values) for a given plot to change from cultivated to long fallow is relatively higher for households headed by females compared to those headed by men. Furthermore, results showed that the chances (odds ratio values) of long fallowing was greater for households with more than one resident wife compared to those with one resident wife.

The most significant variables were related to the plot. The significant differences were observed for variables related to soil fertility, location of the plot in the midslopes and plot distances at a 1% level of significance. For example, results showed that the odds ratios for FERTMOD and FERTGOOD are 5.24 and 9.74 respectively and have the hypothesized sign. This implies that the probability (odds ratios) of long fallowing for poor soils was (about 5 times) higher as compared to plots with moderate soil fertility and about 10 times greater than plots with good soil fertility. The plots under long fallow were more likely to be located far from the homes as compared to cultivated plots. The estimates were satisfactory in terms of the goodness of fit, the signs and levels of significance of individual parameters. The likelihood ratio test statistic tests the hypothesis that the coefficients are all equal to zero. The statistic test rejected the null hypothesis that all the coefficients are equal to zero.

5.4.4 Woodlot and terrace abandonment model

The results from the woodlot model revealed that one household variable (EDUCPOST) was important in determining the farmers' decision to establish woodlots at 5% level of significance. It also had the expected positive sign. Despite low significant levels of about 10% level, the age of household head and education at primary level are positively

related to farmer's decision to use plots for woodlots. HHPMALE was negatively related to farmers' decision to put plots under woodlot. This suggests that woodlots were more likely to be found with older farmers as compared to younger ones. For example, results showed that the odds ratio for EDUCPRIM was 1.513. This implies that the probability (odds ratio) of a plot to be under woodlots increases about 2 times when the plot belongs to farmers with primary education compared to farmers with no formal education. Farmers with primary education and post primary may have more diversified profitable livelihoods and could afford long-term investments other than use of land.

The plot variables that were significant included PLOTSIZE, STONMANY, FERTMOD, FERTGOOD, and SLOPSTP at 1%, level respectively. The variables FERTMOD, and FERTGOOD, reflecting plots with either moderate or good soil fertility had a negative signs and were significant at 1% level. This implies that soil fertility is one of the critical determinants for farmers' decision to use plots for woodlot. The negative sign implies that woodlots are less likely to be observed on the moderate and highly fertile plots compared with poor soils. Woodlots were more likely to be planted on plots with poor soils than on plots with fertile soils.

The plot distance variable (PLOTDIS) represented the plot distance from homes. It had a positive sign but was significant only at 8% level. The woodlots plots were further away from the homes as compared to crop-cultivated plots. The stoniness was another plot variable that was highly significant at 1% level. The odds ratio for stoniness in the woodlot model was 3.373. These results showed that the odds to establish woodlot increased to about 3.5 times among plots with many stones than the odds for plots with no stones. The odds for woodlots on larger plot sizes were greater than the odds for woodlots on smaller plots. The steep slope variable was highly significant at 1%. Farmers establish more woodlots on steeper plots than on gentler plots. The odds for continuous cultivation increase when the plot was on a gentle slope compared to a steep one.

Table 5.12: Estimated coefficients and odds ratio for factors influencing farmers' decisions to either use land for Woodlot or abandon it.

Factor influencing farmers	Woodlot			Abandonment		
	Coefficient of the hh/plot factor	estimate	Odds ratio	Coefficient of the hh/plot factor	estimate	Odds ratio
AGEHH	0.011		1.012*	0.020		1.020***
HHSIZE	0.019		1.020	0.219		1.245
EDUCPRIM	0.414		1.513*	0.781		2.184***
EDUCPOST	0.671		1.956**	-0.058		1.060**
HHFEMALE	-0.132		1.141	0.313		1.368
HHMALE	-0.555		1.742*	-0.398		1.489
TOPTOP	-0.118		1.125	1.073		2.924***
TOPMID	0.243		1.275	0.255		1.290
FERTMOD	-1.950		7.029***	-2.279		9.767***
FERTGOOD	-2.892		18.029***	-2.669		14.425***
STONFEW	0.184		1.202	-0.316		1.372*
STONMANY	1.216		3.373***	0.419		1.520**
PLOTSIZE	0.083		1.087*	0.070		1.073
SLOPMOD	-0.030		1.031	0.739		2.094***
SLOPSTP	0.768		2.155***	0.522		1.685**
PLOTDIS	0.094		1.099*	0.211		1.235***
FARMSIZE	0.097		1.000	-0.006		1.007

*, **, *** denotes statistical significance at the 10%, 5% and 1% level respectively.

hh denotes household. Analysis was done using multinomial logit function against abandonment, woodlot, short fallow and long fallow based on continuous cultivation.

The significant variables that explain abandonment included both personal and plot variables. The estimated results for the abandonment of terrace model are presented in Table 5.12. Three household variables that were statistically significant included, age of the head of the household (AGEHH), education levels of post primary education (EDUCPOST) at 1% level of significance and household size (HHSIZE) was significant at 5% level. For example, education level variable of the farmer was positively related to the abandonment of the plots. The odds ratio value obtained for (EDUCPRIM) was 2.184. This implies that as the variable changes from (No Formal Education) to (EDUCPRIM) while the value of other independent variables is constant, the (odds) chances of a plot being abandoned increases by 2 times.

Household size exhibited a negative relationship to abandonment and was significant at 5% level. This suggests that abandonment was most likely to take place where there are fewer members in the household. Partly it indicates that there was insufficient labor for household with abandoned terraces as compared to households with more cultivated

plots. Furthermore, the farmers with abandoned terraces were more likely to have post primary education compared to those with cultivated terraces. This has two implications; firstly, farmers with post-primary education divert resources to other enterprises other than farming. Secondly, these farmers have less time to attend to full time farming and therefore do part time farming.

The plot level variables related to abandonment that were highly significant at 1% level include location of plots on hill tops, moderate fertility, plots that are fertile, plots on moderate slopes and plot distances from home. The coefficients for the variables moderate (FERTMOD) and good soil fertility (FERTGOOD) had the hypothesized negative sign and were significant at a 1% level. For example, the odds ratios of 14.425 and 9.767 were obtained for FERTGOOD and FERTMOD respectively. This showed that when the variable changes from poor soils to FERTGOOD the relative chances (odds) of a plot being abandoned decreases by about 14 times other factors remaining constant. Furthermore, the odds ratio (probability) of a plot remaining under abandonment decreases more (about 10 times) as the plot changes from poor soil to moderate soil status all other factors remaining constant.

The variable SLOPSTP has the odds ratio of 1.685. This implies that the (odds) probability for the plot to be abandoned is greater when the plot is located on the steep slopes (about 2 times) compared to the odds when a similar plot is located on gentle slopes. Presence of stones (many) and plots on steep slopes are significant at 5% level. Unexpectedly, plot sizes and farm sizes variable for abandoned terraces were similar to those of cultivated plots and did not contribute in explaining the differences in land uses. Abandoned terraces are more likely to be observed on hilltop and mid slopes compared to plots in the valley bottoms. Alternatively, there is greater chance of finding cultivated plots in the valley bottom and abandoned terraces on top of hills than in valley bottoms. Plot slope angles also appear to positively influence abandonment of plots.

The presence of stones was also another factor that influences plot abandonment. The odds ratio value was 1.520. This implies that the odds for the abandoned plots are greater

(about 1 and half times) where there are many stones compared with the odds for it where the plots had few stones.

5.4.5 Comparison of cultivated with non-cultivated land use options

The regression results comparing the alternative non-cultivated land use with cultivated plots are summarized in Table 5.13. The purpose of these results was to use household and plot variables to identify the differences and similarities between land use types and take an initial step to identify distinct types of abandoned and long fallow plots. Abandoned terraces are significantly different from long fallow terraces with respect to location on hilltop, presence of stones, slope angles, household size and post primary education. The results revealed that based on the biophysical variables, abandoned terraces are located on steeper slopes compared to long fallow terraces.

Table 5.13: Relationship between selected factors and land use option in Kabale when compared with cultivable land

Factor	Land use option			
	Short Fallows	Long Fallows	Woodlot	Abandoned
Plot size	Less	Same	Larger	Same
Plot distance	Further	Further	Further	Further
Top of hill	Same	Same	Same	Greater
Mid slope	Less	Less	Same	Less
Moderate fertility	Less	Much less	Much less	Much less
Good fertility	Less	Much less	Much less	Much less
Some stones	Same	Same	Same	Less
Many stones	Same	Same	Greater	Greater
Slope moderate	Same	Same	Same	Greater
Steep slopes	Same	Same	Greater	Greater
Total farm size	More	Same	Same	Same
Household size	Same	Same	Same	Less
Post primary education	More	Same	More	More
Primary education	Same	Same	Same	Same

Key: Less, same, further, describe the relative proportion of the variable in the specified land use relative to the cropped land use option. The cultivable land is held constant and not included in the table above but all options and factors are varying with it.

In relation to household variables, households with abandoned terraces have significantly less members compared to households with long fallows. In conclusion, the results revealed that the coefficients reported could be used to distinguish abandonment from other land use options on the basis of variables included in the model.

5.5 Types of long fallows and abandoned terraces

In order to understand whether long fallows and abandoned terraces can be intensified through improved agricultural innovations it was important to determine whether distinct types exist and if so, which ones could be intensified. Results revealed that the cultivable and uncultivable plots are identified based on characteristics such as stoniness, steepness and location on top of hills. This implies that in order to design appropriate technologies for long fallows and abandoned terraces, the cultivable plots and potentially less cultivable terraces should be identified. The frequency table for long fallows and abandoned terraces in relation to the above characteristics is presented in Figure 5.3.

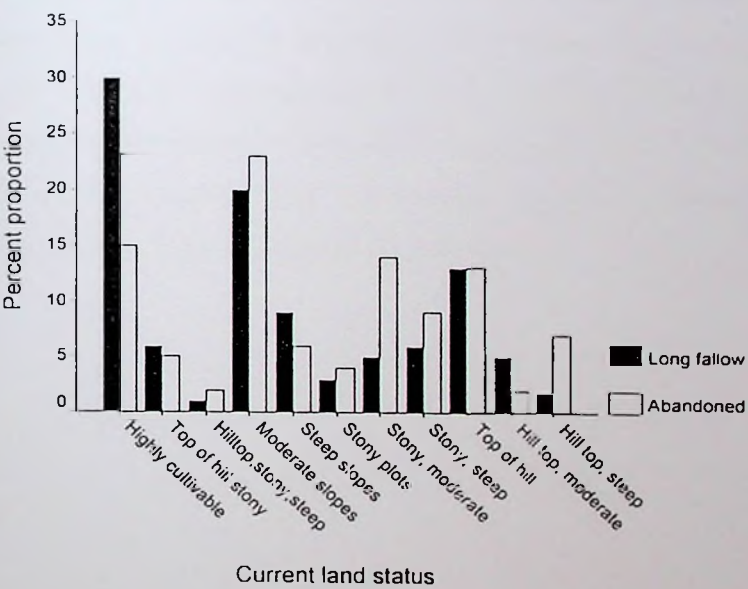


Figure 5.3: Status of long fallow and abandoned plots in Kabale District

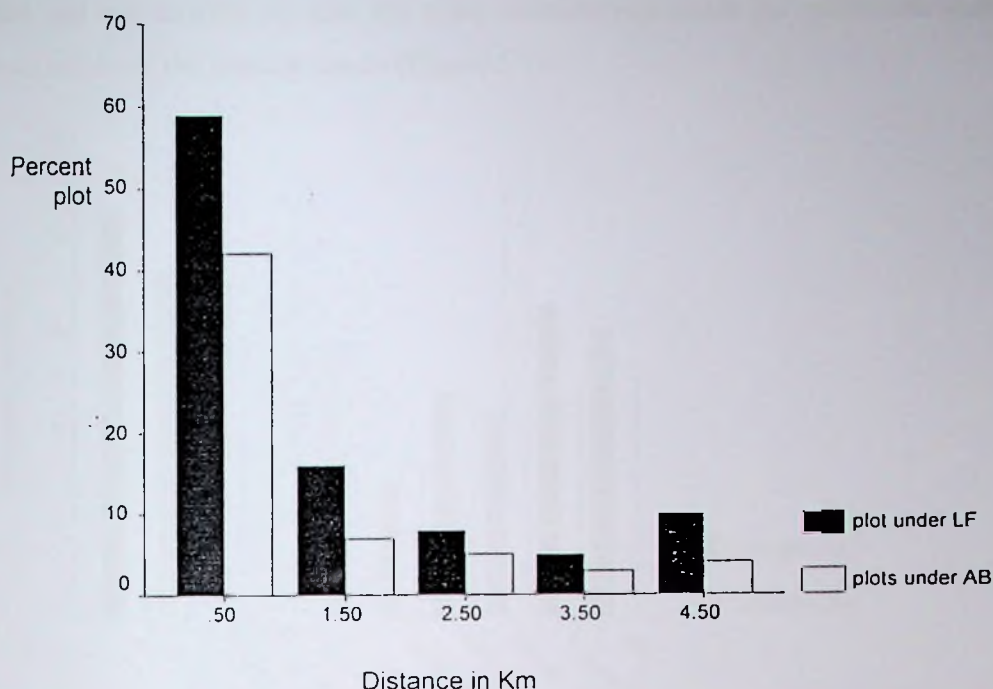
Thirty percent of the long fallows are estimated to be highly cultivable with no apparent unfavourable plot characteristics while another 20% were favourable except for location

on moderate slopes. About 26% of long fallows are potentially uncultivable. These included plots located on very steep slopes and stony areas. This implies that some of the terraces that farmers operate are inherently uncultivable and fragile. Fifteen percent of the abandoned terraces were cultivable with favourable characteristics while 23% percent of the abandoned terraces are located on the moderate slopes with good characteristics. More than 40% of the abandoned terraces are located on inherently uncultivable and fragile areas such as stony and very steep areas.

Consequently, it requires a lot of effort to intensify plots that are uncultivable. It would be appropriate to initiate enterprises that keep these areas under continuous cover unlike the annual and continuous cultivation as currently practiced. Furthermore, the policy implication is that by-laws that specifically address these inherently uncultivable and fragile areas need to be put in place and emphasized. Getting a clear understanding of the circumstances that lead to abandonment and long fallowing of the highly cultivable plots requires further analysis as shown below.

5.5.1 Cultivable long fallows and abandoned terraces in relation to distances

The distance from home was used to investigate further the cultivable long fallows and abandoned terraces. Thirty four percent of cultivable long fallows are located within 0.5 km. Forty seven percent are located between 0.5 km and 2km while 19% of the cultivable long fallows are located beyond 2 km. As a result, a bigger proportion of cultivable terraces under long fallows is far and not easily accessible.



LF and AB denote Long Fallow and Abandoned Terraces respectively.

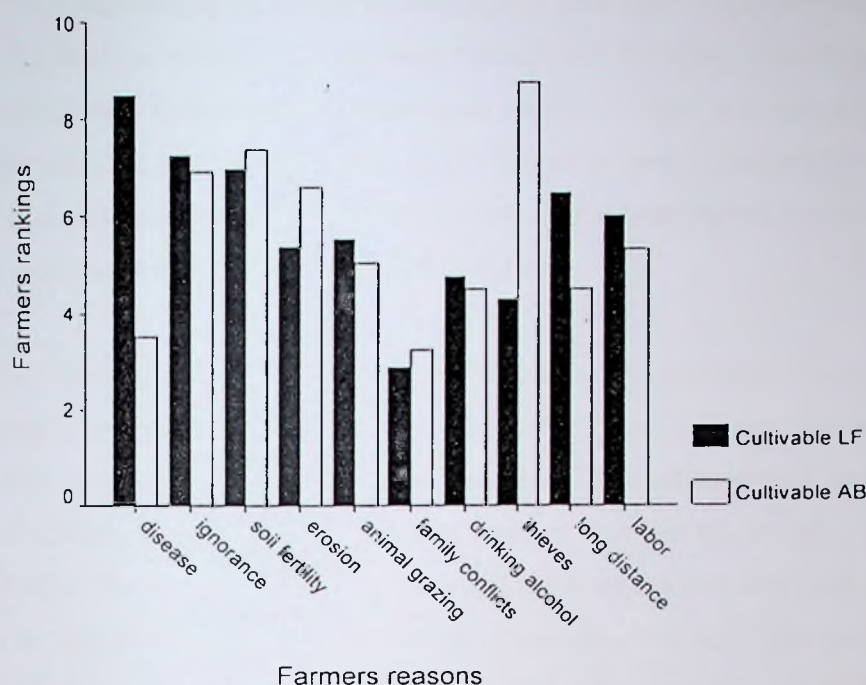
Figure: 5.4 Showing how cultivable long fallows and abandoned terraces vary in relation with distances from home.

Forty two percent of cultivable abandoned terraces are located within less than 0.5 km. Thirty five percent were located between 0.5 km and 2km while 22% of the cultivable abandoned terraces were located beyond 2 km (Figure 5.4). Factors leading to near plot abandonment are not clear but absence of labour was assumed to be partly the problem. This analysis revealed that some of the cultivable but abandoned terraces are caused by inaccessibility. This implies that abandoned terraces are most likely to be further away from the homes hence making management of plots even harder. This suggests that different sets of technology and policy intervention measures may be appropriate for different land uses especially for terraces that are currently idle.

5.6 Farmers' evaluation of cultivable long fallow and abandoned terraces

The farmers' main reasons for leaving cultivable plots under long fallows are crop diseases and lack of soil management information on the part of farmers. Thieves, soil

erosion and soil fertility are also the other reasons responsible for cultivable abandoned terraces and have the highest scores (Figure 5.5).



From the legend Cultivable LF denotes Cultivable Long Fallow and Cultivable Abandoned Terraces.

Figure 5.5: Farmers' reasons for having cultivable long fallows and abandoned terraces in Kabale District.

Other important reasons for both long fallows and abandoned terraces include long distances to cultivable plots, animal grazing and labor availability. Farmers revealed that they are aware that planting contour hedgerows, woodlot and digging trenches can help but access to enough tree seedlings and labour to dig up trenches is not available. The farmers realize that training in farming practices and seedling production is essential.

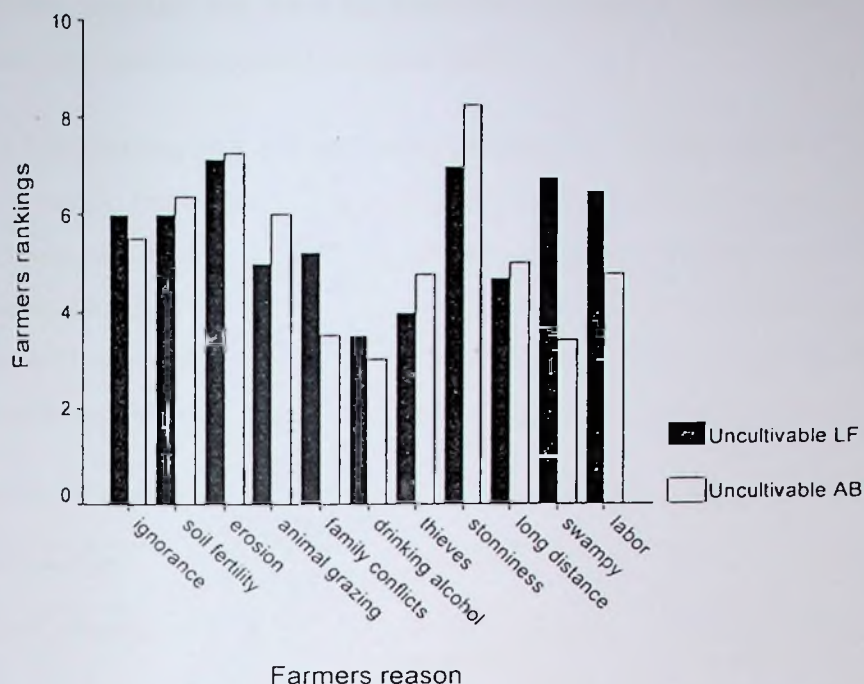
Although farmers pointed out the problem of loss of soil fertility as a reason for lack of cultivation, approaches to improve productivity through use of fertilizers is minimal. Artificial fertilizer is expensive for poor farmers and few farmers use leguminous shrubs and trees to improve soil fertility. This is because leguminous tree seedlings required for a given plot are expensive and tree seeds are not commonly available to farmers. It also requires a lot of labour to carry and establish them on scattered plots. The seedlings also

take sometime before they establish to deliver positive net returns. Farmers revealed that land conflicts are common both on boundaries and among family members. These also are partly responsible for failure to utilize plots profitably. Disagreements in families and alcohol drinking sometimes keep land uncultivated for along time despite being fertile. Female farmers complained that most men spend a lot time drinking alcohol and have no energy and time left for work in the fields. Female farmers requested for a bye- laws to be put in place to restrain men who drink all day so that drinking hours can be limited to non working hours especially evenings and at night.

Animal grazing contribute to the long fallows and abandoned cultivable plots. Free grazing is common and has caused some plots to be abandoned. Farmers suggested that by-laws are needed to stop these free grazers. The challenge here often is the corrupt local officials. Either a defaulter bribes them or they are the owners of the animals. In such cases, the transaction costs of getting fair justice became very high. Long distance is also another problem that causes farmer to abandon the cultivable fields. Furthermore, these plots are scattered on the landscape. Farmers suggested the exchange of the far fields could help to minimize the distances but required a lot of negotiations. Furthermore, they suggested that producer organization where farmers would combine to grow one specific crop irrespective of plot size would be another strategy. This approach requires that farmers with plots on a given hillside agree to cultivate a common crop such as potatoes. They use common management techniques in order to attract higher prices through organized farming and marketing practices. This can help to minimize abandonment of plots.

5.6.1 Uncultivable long fallow and abandoned terraces

Farmers observed that most uncultivable plots are kept under long fallow because of being stony and located on steep slopes where soil erosion is common. Farmers leave such plots uncultivated for more than 3 years and subsequently uncultivable long fallows are turned into common grazing grounds, which are heavily eroded. Farmers in Maziba and Kashambya commonly raised issues of overgrazing and bush burning. Farmers suggested that byelaws to protect these fields from grazing and burning should be made.



From the legend Uncultivable LF denotes Uncultivable Long Fallow and Uncultivable AB denotes Uncultivable Abandoned Terraces.

Figure 5.6: Farmers' reasons for having uncultivable long fallows and abandoned terraces in Kabale District.

Distance from homes was also a problem for the uncultivable plots either left under long fallows and abandoned for along time without being used. Farmers suggested that owners of these far fields could exchange them for the near ones and minimize the problem of fragmentation. However, disagreements among members whereby each insists that their plots are better and more fertile than the neighbors remains the challenge. This makes exchange of land difficult and slows the process of consolidation. As a result some farmers may prefer to spend hours traveling to their plots than negotiate with those farmers neighboring their plots.

Uncultivable abandoned terraces are stony and those in valley bottoms are sometimes swampy and could be flooded some parts of the year. The farmers suggested that such fields could still be used to generate some income such as sale of stones for construction and also establishing fishponds in the valley bottom. Transportation systems on the hill

slopes are commonly difficult where uncultivated abandoned terraces are located. Farmers suggested that since the district has a budget for rural roads, it should construct them to increase accessibility to these hills.

5.6.2 Minimizing plot distance and participatory approaches to improve land use

Both results from regression analysis and participatory meetings suggest that distance between plots highly influenced plot use by farmers. Consequently, farmers and policy makers identified land consolidation as a prerequisite to modernization of agriculture. However, it requires policy intervention in form of either incentives or disincentives (regulations) where applicable to minimize farmers' tendencies to acquire several plots.

Table 5.14: Participatory response on the desired strategies to improve land use.

Land use type	Proposed technologies	Desirable strategy	Desirable incentives from government
Annual cropping	Improved agronomic practices Improved seed/seedling Contour hedges Terracing	Land consolidation Controlled grazing	Alternative economic activities Fertilizer
Cultivable long fallow	Improved fallow species High value crops Improved seed/seedling Trenches Contour bunds	Consolidation Controlled grazing Regulation Plot exchange/renting	Availability of • Fertilizer • Improved fallows
Uncultivable long fallows	Rotational woodlots	Regulation Stop fires Land evaluation	Availability of • Seed/seedlings • Fruit trees
Cultivable but abandoned	Improved fallow species High value crops e. g fruits Improved seed/seedling Trenches Contour bunds	Enforce rights Political will to minimize transaction costs Plot exchange/renting	Availability • Fertilizer • Improved fallows • Rotational woodlot
Uncultivable and abandoned	Rotational woodlots	Regulation Stop fires	Availability • Seed/seedlings • Fruit tree • Leguminous woodlots

Improved agronomic practices includes crop rotation, mulching, integrated pest management, manure application and other feasible options

Results revealed that there is need to activate a combination of byelaws and technology generation to minimize abandonment (Table 5.14). Farmers and policy makers revealed that the following could help improve use of long fallow and abandoned terraces.

(i) To enforce policies/by-laws by the communities in collaboration with local and district leaders to minimize abandonment.

(ii) Do more research as regards to technologies, markets and attitudes to work. Furthermore, farmers proposed some technologies and desirable strategies that could address the problem.

5.7 General Discussion

This section seeks to discuss important biophysical and socio economic characteristics that influence farmers' land use decisions with particular emphasis on abandonment and long fallow. The findings from biophysical analyses revealed that plots with particular characteristics were likely to be under a given land use options. The body of literature on the importance of plots related characteristics as a major determinant for land use systems have been highlighted in several studies e.g. Kakuru (1995), Raussen and Ong (2000). Socio-economic findings helped to predict whether particular categories of people are more inclined to use terraces in a particular manner than others do. For example, Pender and Duron (1998) and Pattanayak and Mercier (1998) revealed that socio-economic characteristics influenced farmers' behavior and attitudes towards soil and land management. Based on these findings, researchers and development workers could tailor their innovations for different land use options to prospective policy makers and farmers.

5.7.1 Extent and characteristics of abandoned and long fallow terraces

The analysis used rigorous approaches that involved a large number of farmers and plots. Results from this study revealed some similarity to previous studies (Lindblade, 1997) and Carswell, (2002) in terms of the total land area left uncultivated. The extent of uncultivated land for a long time was about 30% of the land use. Use of econometric approach helped to distinguish between land fallowing and abandonment and explained farmers' reason for fallowing. These empirical findings revealed that abandoned and long

fallow terraces are common and significantly different from each other in terms of several parameters. For example, while long fallows are similar to cultivated plots in terms of household size, households with abandoned terraces had smaller household sizes relative to farmers with cultivated crops. This has two implications. Firstly, plots left for a long time can be re-cultivated because they have regained fertility. However, results revealed that abandonment was caused by several factors other than soil fertility. Secondly, it delays uptake of appropriate technologies for improved land use options as long as the problem is not addressed.

5.7.2 Determinants of land use options

Socio economic factors that influence farmers' decisions on short fallow land use include post primary education and farm size. Results suggested that farmers with post primary education are more likely to practice short fallow compared to those with lower education. It is possible that farmers with post primary education are more aware of the dangers of continuous cultivation and therefore ready to forego some benefits in the short interval before they re-cultivate plots in the next season. Furthermore they may have had some agricultural education in schools. Farmers with primary education are similar to those who have never gone to school and appeared to be less willing to forego the same benefits and continue to cultivate. Farmers with large farms can afford a short fallow. The possible explanation is that farmers with larger farm size could afford to leave some plots uncultivated in order to regain soil fertility unlike farmers with smaller farm sizes. Since farmers have little access to fertilizer (See Appendix 3) the only option left for those with large farms is to use fallowing as a strategy to improve productivity.

The plot level variables that influence short fallow decisions include plot distance from home, soil fertility and plots located on the mid slopes in terms of distance. Farmers found it easier to cultivate plots that were nearer home. As a result, plots that were far from home were likely to be under short fallow compared to plots that are near home. Plots that were less fertile were also found to be either under short or long fallow. Generally, soil fertility decreased for most plots that were continuously cultivated and lacked external fertilizer. Also Grisley and Mwesigwa (1995) observed that in the

absence of external fertilizer there was need to introduce other measures that would improve soil fertility.

Farmers age, polygamous households and households headed by women had an influence on farmers long fallow decision. Older farmers left plots to long fallow compared to younger farmers because partly older farmers have more land compared to younger farmers. Older farmers can afford to leave some plots to long fallow while they use extra plots for crop production. Polygamous households had more land under long fallow compared to monogamous households. It is expected that more women by the household head could mean more labor for the household. However, it appears that men who are polygamous have more land, which motivates them to get more women to cultivate it. Households headed by females have more land under long fallow. The explanation for this occurrence is that, female-headed households do not have enough labour and other resources to cultivate all the plots available to the family.

Farmers' age, education and polygamous households had influence on woodlot establishment. Older farmers have more woodlots compared to younger farmers. They could afford to have more plots allocated for woodlots compared to young farmers. For example, female-headed household has fewer woodlots. This is explained by the fact that tree farming is considered as an enterprise for men. As a result, few women would make effort to grow trees. Farmers with post primary education are more inclined to put land under woodlots compared to farmers with primary education or less. Farmers with post primary education have several plots of land but are not available to cultivate them since some have paid jobs elsewhere. As a result, farmers prefer to put such plots under long-term enterprise that generate income in their absence. Farmers know that growing of trees brings more benefits compared to other enterprises on idle plots. For example, woodlots produce stakes for climber beans, building poles, firewood and sometimes timber. Therefore wealthier and more educated farmers prefer to establish woodlots on plots that are not used for crop production.

The plot level characteristics that influence farmers to put land under woodlot include soil fertility, presence of many stones and steepness of the plot. The plot related variables that significantly explain farmers' decision to long fallow are plot distance and soil fertility. Results revealed that when plots lose soil fertility, they are more likely to be left fallow. Plots with stony soils are commonly used for woodlots partly because these areas are least suitable for agricultural production. Trees are the only crop that could tolerate areas that are stony, infertile and steep. During colonial times, steep slopes were left uncultivated because laws were strictly observed. Due to population pressure and poor governance, these areas were converted for agricultural production, which proved counterproductive. Cultivation on steep slopes has led to landslides, which increases loss of nutrients and leads to abandonment of terraces.

Some household variables significantly influence farmers' decisions to abandon plots compared to other land use options. For example, household size influenced farmers' decision to abandon plots. Households with fewer members abandoned more plots compared to those with more members. The explanation is that due lack of cash to hire in labour, households resort to family members as a source of labour. Therefore if a household has few members, it is unlikely to cultivate all the plots. Farmers with primary education abandon more plots compared to those with post-primary education. It appears that farmers with little education have little appreciation for new technologies to improve output and are less willing to take risks. Consequently, it is common for such farmers to migrate to other districts in search of fertile land.

Critical analysis of the different types of long fallows and abandoned terraces revealed that several factors influenced farmers' decisions to long fallow and abandon terraces. For example more abandoned terraces are located on the stony moderate slopes compared to long fallows. More plots under long fallow are cultivable compared to abandoned terraces that are less cultivable. The implication is that technologies and policies to address abandoned terraces might significantly differ from those to address the problem of long fallows. For example, previous policies were based on the gradient of the plots. Plots above 30% gradient were either left to fallow for longer periods while all plots

below 30% could be considered cultivable. These results suggests that other factors besides hill slopes are important in making policy decisions for designing technologies to improve a given land use option.

Use of quantitative techniques has led to the conclusion that there are distinct differences between the non cultivated land use options from the cultivated ones based on both household and plot characteristics. Furthermore, it was consistent with economic theory of subjective decisions making under uncertainty and utility maximization that views some of these land use options as sub optimally utilized and therefore requiring different approaches to improve output.

The findings indicate that soil fertility, post primary education and female household headship significantly contributed to farmers' decision to put land under abandonment and fallow. However, some plots were inherently cultivable and some are inherently uncultivable. This implies two things. It requires effort and a different set of policies to optimize output from inherently uncultivable abandoned and long fallow terraces. Secondly, technologies and major limitations for the cultivable plots need to be identified and appropriately applied. Therefore, it is appropriate to initiate enterprises that keep uncultivable areas under cover instead of the annual cultivation as currently practiced.

It is possible for farmers to leave land unsuitable for other uses idle for several years, at least in the medium term. However, farmers are not able to maximize benefits and improve their welfare when part of their vital resource (land) is sub optimally used. If not addressed there are other long-term associated costs with long fallow and abandonment that include destruction of the terrace risers, which not only affects agricultural output but has capacity to accelerate erosion, cause negative off site effects and erode the scenic beauty of the highlands. In such a case, it can be concluded that addressing the problem using both policy and private (farmer) approach could help to develop sustainable agricultural production system to support the rapidly growing population and reduce degradation of the resource base. Arguably, natural fallow and continuous cultivation make farmers exploit themselves through resource mining.

The model specified information vital for efficient land use decisions. However, it adds value to work provided by previous studies on land use and degradation in Sub Saharan Africa. Previous work provided little value to land users and to policy makers, but only served as an indicator of a problem and relative magnitude of land use options. It is recommended that micro level modeling approaches be encouraged. It is of greater value to land users and policy makers than the aggregate and descriptive studies of the past in the region.

Understanding of the farmers land use decision making process plays a significant role in planning and implementing the rehabilitation of abandoned terraces and help to identify potential and improved technologies for long fallow plots. One option could be to put uncultivable long fallows and abandoned terraces into permanent land use system. For example, leguminous rotational woodlots could be implemented on abandoned terraces. Cultivable long fallows and abandoned terraces could be identified for farmers who want to form producer groups to produce common high value crops that favor environmental friendly management practices on the hill slopes such as apples and other tree species for reforestation of sloping lands.

5.7.3 Policy options and land use options

There is need to develop policies to improve agricultural production and improve natural resource management on long fallows and abandoned terraces. These could involve development and dissemination of new agricultural technologies. In most cases, these require some extra resources for research and development in both private and public sectors. In the early stages, more resources are needed to be in public sector as it is necessary to develop basic knowledge in order to come up with a wider range of options to address the different types of long fallows and abandoned terraces that are a major natural resource management problem.

Addressing only on-farm disincentives that lead to sub optimal use of terraces is inadequate because poor land use leads to major offsite effects, which may not borne by

farmers. For example, several years ago Kabanyonyi dam that produced and supplied electricity to Kabale town was closed due to silting and landslides. In addition, farmer's time preference is much shorter and their discount rates much higher than that of the society at large. Therefore public intervention and national actions may be required to ameliorate the effects of long term effects of poor land use and degradation including better defined property rights, government regulation on land use and public investments in reforestation and soil erosion control projects.

Kigezi highlands are more dependent on natural resources notably land and water and land degradation significantly threatens agricultural growth in this part of the country. Therefore improved land use is of great importance to sustainable economic development. In the long term, land protection and agricultural growth are complementary rather than competitive even though there may be some trade off between the two in the short term. As a result, policy reforms may be needed to protect the natural resource base. Households operate sub optimally on most land use systems. This needs to be brought to the attention of various stakeholders such as politicians, researchers, extension staff and the local people. The study shows that the technology recommendations and improvements need to be site specific rather than general recommendations for the entire region. For example, the study revealed that distance to fields hinders the optimal use of these terraces. As a result, based on the location and other relevant factors, policy makers farmers and other stakeholders need to consult and find profitable approaches to encourage free exchange of land, renting and selling of far off plots.

It may be necessary to design policies specific to a land use type focused on increasing direct economic incentives for improved land use. The main purpose of such policies should be to increase economic returns of existing land use options as opposed to encouraging farmers to migrate to other parts of the country where land may still be abundant. Households and small farms perform most agricultural activities on small units of farms; appropriate incentives for the small farmers are vital.

Results of the present study revealed that road network as major factor in minimizing sub optimal use of plots especially land abandonment and had a positive sign. Therefore, policies that can help to constructs roads to land on hilltops and other areas with potentially useful land are needed. This could imply that extension officers could easily access these plots. Secondly, the road network could improve the land market and make it more competitive for high yielding options and this could improve the economic condition of farmers. Furthermore, it could motivate them to start land titling and eventually promote less idling of potentially productive land.

Previous policies related to cultivation on steep slopes were of general nature and only governed by biophysical factors. There is need to design policies taking into consideration personal factors such as household size and age of the household head. For example, incentives need to be put in place for farmers with smaller household sizes to dispose of land that they may not use. Furthermore, older farmers could be motivated to put land into enterprises that keep it under cover or dispose the same plots to younger and progressive farmers. Abandonment is associated with primary education or less. There is need to improve the education of the rural people since this will improve their understanding and knowledge of soil management and increased output.

In conclusion, the results reveals that the coefficients reported for land use options can be distinguished from other land use options on the basis of variables included in the model. Furthermore, the current study shows that abandonment, long fallows and other land use types are common and significantly different from each other. The optimal policies should be developed to improve output from the most degraded terraces. The required improvement in productivity may not take place voluntarily in most cases.

CHAPTER SIX: CONCLUSIONS AND POLICY RECOMENDATIONS

6.1.1 Introduction

Plot abandonment and long fallow of terraces leading to sub optimal land use option has become a serious land use problem in Kabale. Concerns over abandonment arise because of its significant effect on household food security, nutrition, financial and economic loss, and natural resource degradation. Consequently, several cases of out migration to other districts with virgin land, idleness of able-bodied men in rural areas, unskilled laborers seeking off farm income outside the district are not uncommon. The problem is compounded by the fact that previous research did not pay sufficient regard to farm level critical socio-economic issues and farmers' perception to the sub optimal use of land resource. The study observed that potential causes of abandonment and long fallow include biophysical and socio-economic factors such as unimplemented policies, lack of appropriate innovations and lack of sufficient capital to invest in the degraded areas.

This thesis sought to analyze long fallow and agricultural land abandonment in the intensely cultivated areas of Kigezi highlands in order to suggest interventions to improve both farm level and national outputs. At farm level, the main objectives were twofold: To determine the extent and estimate the plot and household level socio-economic determinants of cropland abandonment and long fallow decisions of farmers. At institutional level, the study examined the major constraints that limit implementation of by-laws and evaluate policy options, innovations and incentives that could increase economic output from abandoned terraces. The conclusions and policy recommendations below are based on the above objectives.

6.1.2 Conclusions

Firstly, from the results, it can be concluded that long fallow and abandoned terraces are common, and comprises over 25% of the land area. They also differ significantly from other terraces in terms of household and plot characteristics. Secondly, model estimates reveal that the coefficients reported for abandoned terraces can help to distinguish them from other land use options on the basis of the variables included in the model. Lastly, new policies need to be developed based on new findings to improve output from sub

optimally used terraces as previous policies were based on qualitative assessments. Unless addressed, the regression results confirm the researchers belief that the different land options examined in the study are significantly different and constitute an immediate as well as a potential long term threat to the regions capacity to produce food unless the challenge is addressed.

6.1.3 Policy implications

Therefore, it is recommended the state provide some appropriate incentives to farmers. One of the incentives could be to encourage farmers with such plots to collectively grow high value crops, which farmers can manage on specific landscapes where these long and abandoned terraces are common.

6.1.4 Research limitations

The limitations of this research study were centred on the volume of data on which the findings and recommendations are made. The specific limitations of the study are outlined below. The farm level data collected were mainly for one season. Data covering more years would best meet the objectives of this study as it would relate more closely to farmers production practices.

Due to time and financial limitation, this study focused mainly on Kabale district. While this can be extrapolated for Kigezi highlands as a whole, this may not be true for other highland areas in the country because of varying socio-economic and climatic differences. No valuation was done for the activities that farmers engage in (the opportunity cost of labor) when farmers are not involved in agricultural activities. Many farmers do not keep records of their operations hence most of the information supplied was by recall, sometimes assisted by other members of the households. In some cases, the farmer would fail to recall correctly all the number of plots and their sizes. As a result, the answers may not always have been accurate.

6.1.5 Direction of future research

Various issues are either not covered by the present study or are covered but not in depth. Further work is recommended which might contribute to a better understanding and efficient use of land. For example, this snapshot analysis of abandonment and other land use systems could not capture the relevant positive and negative effects on profits for each land use option. Further research that enables one to know what is gained or lost for the various forms of degradation would improve our understanding of the complex interaction between environment and economic factors.

The amount of land held by the household appeared to be (3-4 times) higher than that commonly quoted in many scientific papers (<1ha). There is need to identify an appropriate methodology to come up with a correct area for the households as well as for the highlands. The implication of this is that the area of underutilized land could be much higher than the estimated which could be potentially dangerous. Furthermore, since abandonment and long fallow could vary across other areas that are heavily cultivated, it is essential to have similar studies done in such areas especially where degradation of land is perceived to be a serious problem.

To employ an economic model successfully, there is need for a further study of the relationship between the different land use options and crop productivity to further validate the model. Further research on crops for the long fallow systems is needed to determine the overall economic and biological diversity of the system. This would serve two purposes, provide data for use in identifying possible areas of improvement in terms of efficient use of the resource leading to improved output and secondly, provide baseline information for the comparison and evaluation of new or introduced enterprises. This would help extension personnel to advise land users and policy makers to devise appropriate incentives to deal with inefficient land use. In absence of this information, suboptimal decisions on private lands use may be made. Consequently, public policy measures to remove external effects to land use actions may also be inefficient.

The snapshot findings of this study imply that the current technology in use may not lead to sustainable management of the highlands. Furthermore, this information does not allow a national analysis of the interaction between environmental and economic factors over time. To investigate these issues further, there is need for regular surveys that integrate environmental and economic information in order to monitor and evaluate the changes in these land use options. Lastly, the feasibility of providing credit, producer organizations, provision of incentives to discourage long fallowing/abandonment and increased land exchanges needs to be carefully investigated in order to improve output.

Further research into land price in relation to land use in SW Uganda could help to understand the variations in value between different land use systems. Here it is assumed that the sub optimal land use options by farmers are reflected in land values. At present there is uncertainty about the impact of long fallows, degradation and abandonment on land values.

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Appendices

1: Definitions

This study builds on the previous informal surveys in which farmers in Kabale district revealed that some of the terraces that appear to be in fallow were in reality abandoned. Agroforestry Research Networks for Africa (AFRENA 1999), Network of Uganda Researchers and Research Users (NURRU 2001). The purpose of this study is to further explore this proposition using both qualitative and quantitative techniques to examine the extent and social economic determinants of farmer's decision to put land under different land use options. In this study, the uncultivated land will be referred to as either land under intentional or unintentionally fallow (abandoned). Therefore, long fallow will be defined as a practice where farmers intentionally leave formerly cropland without crops to rest with the purpose of restoring soil fertility. Abandonment will be referred to as a practice whereby farmers unintentionally leave former croplands uncultivated with no plans to bring them back to crop production in the short term (5-10) years.

Continuous cropping will be defined as a practice, whereby farmers cultivate annual crops continuously on a given plot. Seasonal fallows are practices whereby farmers leave short periods of rest between cropping periods normally not more than a year. These rest periods are short term in nature and farmers are only waiting for the next planting period. Woodlot planting is a practice whereby farmers cultivate woody tree species on a piece of land on a permanent basis. Although previous studies (Farley 1996, Lindblade 1997) tend to label all uncultivated land as managed fallow, there appears to be both real and perceptual distinctions between short fallows, intentional fallows and unintentional fallows. Therefore, the study proposes to classify uncultivated land in Kabale as under short fallow, long fallow, woodlots and abandoned land. This research alters the view on the conventional description of fallow in the densely populated Kabale district.

2: Expected output from various land use options

Land use	Farmers Intentions	Expected Duration	Typical Vegetation	By-products
Continuous cropping	Crop production	Permanent	Annual and perennial crops	Crops
Short natural fallow	Quick improvement of soil fertility (gap between seasons)	1 season (< 6 months)	Indigenous herbs	Pasture
Long natural fallow	Improve soil from a low level of fertility	< 3 years	Indigenous herbs and shrubs	Pasture, medicine, ...
Improved fallow	Investment in rapid improvement of soil	1 to 2 years	Planted exotic / indigenous N-fixing shrubs	Firewood
Rotational woodlot	Obtain wood products where fertility is bad; eventually improve fertility	> 2 years	Planted exotic / indigenous N-fixing trees	Soil fertility improvement
Abandoned Land	Field with problems for which farmer has not intention to use in the foreseeable future	> 3 years	Indigenous herbs, shrubs and trees	Communal pasture, medicine
Pasture	Land permanently used for grazing animals (often valley bottom)	Permanent	Indigenous or planted grasses	
Woodlots	Land used permanently for the production of wood (often marginal land)	Permanent	Planted exotic trees	Wood, poles, timber
Gardens	Land for horticultural use (often near the homestead and in valley bottoms)	Mainly permanent	Planted vegetables and fruit trees	

3: Fertilizer Use in Uganda as Compared to Few Selected Countries (metric tons)

	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
Rwanda	500	1000	1000	659	1211	667	945	498	665	448	2000	0
S Africa	27000	10300	37574	33000	34000	2000	40456	13047	33000	53000	40000	41000
Tanzania	11438	21000	31595	18546	28117	36354	33000	27541	33928	31254	37000	20000
Uganda		400	200	262	789	107	250	92	500	400	1300	1500
Zaire	4107	4500	3600	966	3100	1900	6900	4000	4000	1000	3000	3000
Ethiopia	22900	11000	31255	24176	22382	30200	38000	42100	43000	53200		
Ghana	11000	5600	4900	4100	5140	7049	14029	6900	7000	7000	3096	5000
Kenya	31000	35961	57530	63718	45445	67787	45000	57000	51100	46000	49787	59000
USA	12847016	13449793	12545013	12395739	12743891	12715106	13252864	13369665	13376479	13415237	14557267	1353454
Canada	1157200	1255100	1225000	1144600	1160200	1160166	1197188	1157764	1253287	1317643	1405923	1302941

Source: FAO Fertilizer Yearbook Volume 45 (1995)

4: Measurements and Expected Signs for Land use Models Explanatory Variables

Plot Variables.

Variable name	Definition	Type of variable	Expected relationship	Source of data
State of the plot	Activities currently carried out on the plot	Nominal	++ or --	Interview/ visit observ
Time since when	Length of time under current status	Continuous	++ or --	Interview/ Recall
Plots specify crops	Crops grown by names	Nominal	--	Interview/ Recall/ observ
Field before acquisition	Status of the plot before acquisition	Nominal	-- or ++	Interview/ recall
Times cultivated last 5 years	No. of times plot was cultivated	Nominal	--	Interview/ Recall
Soil (classification)	Type of soil as described by farmer	Ordinal	-- or ++	Interview/ observ
Stoniness	Stone rating in the plot	Ordinal	++	Interview/ observ
Fertility	Plot fertility rating by the farmer	Ordinal	--	Interview/ observ

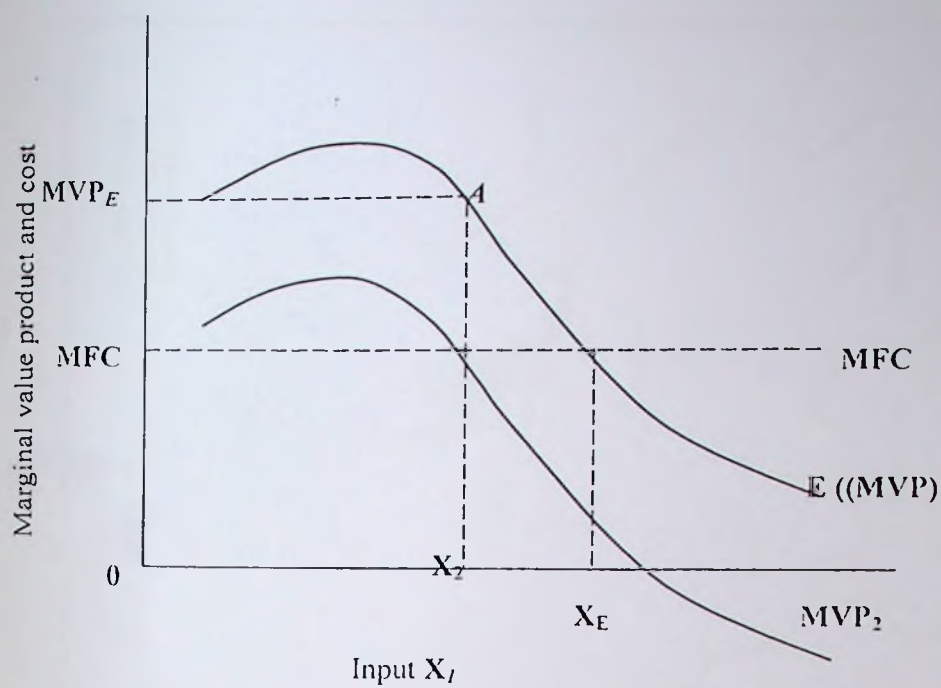
Household variables

Variable name	Definition	Type of variable	Expected relationship	Source of data
Members of household	List of all members of household	Discrete	++ or --	Interview
Age	Age of all members of household	Continuous	++	Interview/Recall
Education	Highest level of education	Ordinal	--	Interview/ recall
On farm	Does hh work on farm	Nominal/dicot	--	Interview
Member of Group/ Association	Does hh member belong to group or orgn	Nominal/Dicot	--	Interview
Off-farm employment	Does hh member have Off-farm employment	Nominal/Dicot	++	Interview
Animals kept	Number of animals kept by the household	Discrete	++	Interview
Type of the main house	Type of main house owned by the household	Ordinal	--	Interview/obser
Number of plots	Total number of plots owned, given out, etc.	Discrete	--	Interview/ visit
Reason for sale	Why hh chose the particular plot for sale	Nominal	++	Interview/Recall
Use of outside labour	Labour other than family labour used by hh	Nominal	--	Interview/recall
Land rented	Whether hh rents land in last 5 years	Nominal /dicot	++	Interview/ recall
Leadership role	Does hh member have any leadership role	Nominal/dicot	--	Interview

Plot Characteristics

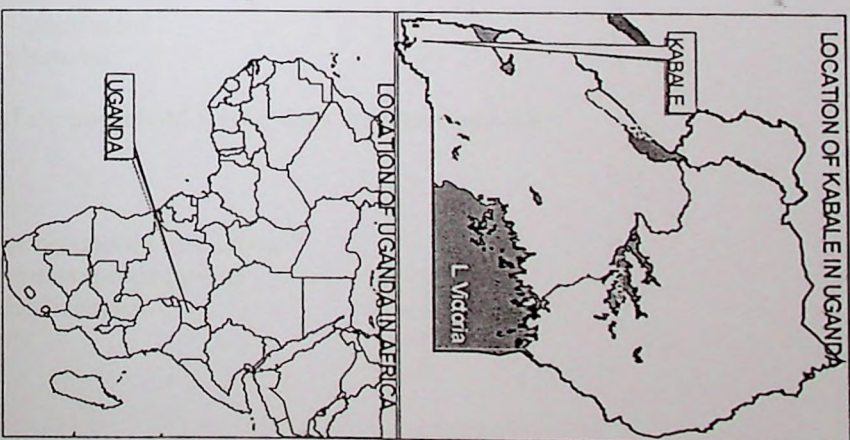
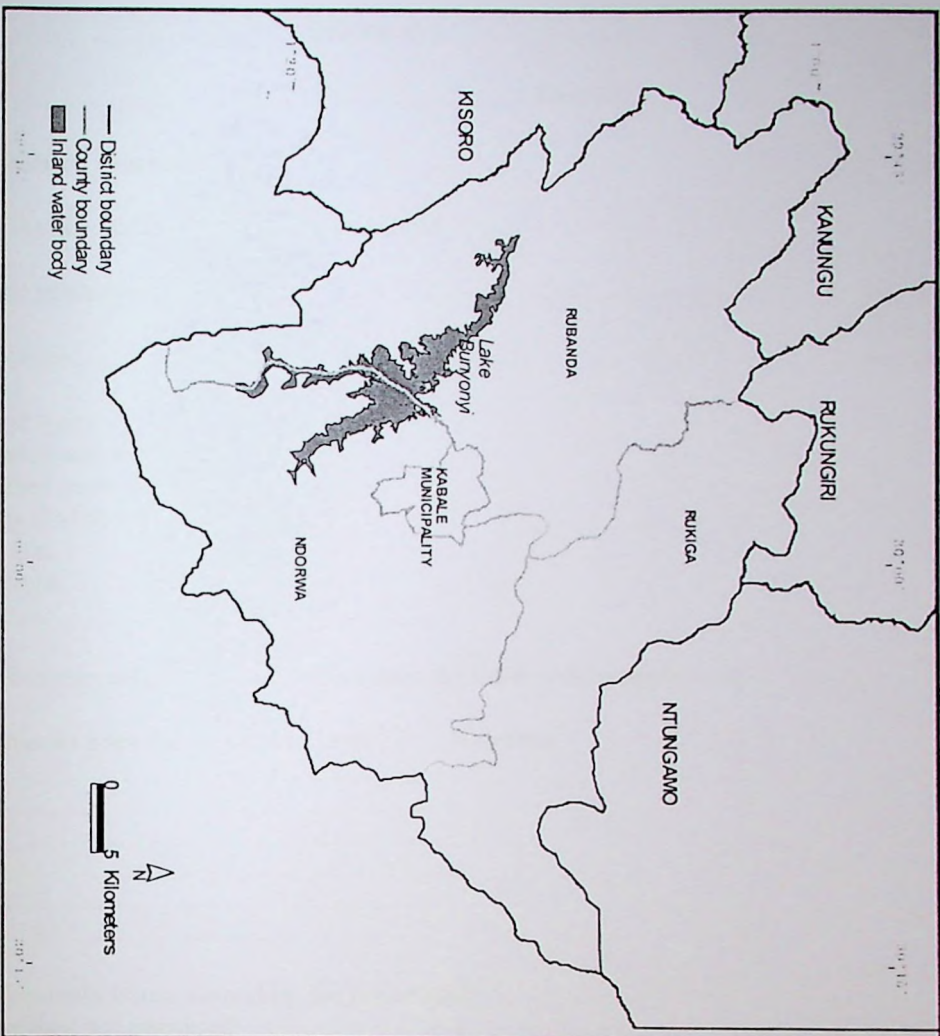
Variable name	Definition	Unit of measure	Type of variable	Expected relationship	Source of data
Area of plot: Length	Total Plot Area	M ²	Continuous	--	Interview/visit/measure
Slope	Gradient of the plot	Degrees	Ordinal	++	
Location on landscape	Topographical location of the plot		Ordinal	++	Interview/ visit
Year acquired	Year when the plot was acquired or no years farmer has plot		Continuous	+-	Interview/recall
Distance from home	Distance of the plot from home	(km)	Continuous	++	Interview/observ
Acquired by extension	Whether the plot has been visited.		Nominal/ Dicot	--	Interview/recall
Distance to market	Distance to closest market	(km)	Continuous	++	Interview/observ
Distance to road	Distance to closest road	(km)	Continuous	++	Interview
Total capital	Total capital Resources other than land owned by hh	Cows	Discrete	--	Interview/ visit
Number of plots	Number of plots owned by hh	Nos.	Discrete	++	Interview/visit
Method of acquisition	How the plot was acquired		Nominal	+-	Interview

5: Marginal Value Product Under Risk



Source: Adapted from Ellis 1998

Appendix 6a. Map of Kabale District showing the surveyed counties



6b: Questionnaire for Abandoned Terraces

Interviewer:.....Date:.....

Village:.....Subcounty:.....

County:.....District:.....

Farmer related Questions

Name of the head of the head of the household

Number of years spent in this village.....

Place of origin.....

Household type:

Male headed one wife... 1

Male headed more than one wife 2

Female headed no husband..... 3

Single man 4

Singlewoman:.....5

Others..... 6

If more than one wife: how many wives does the head of household have.....

Which animals does the household keep: Numbers

Cows:.....

Goats:.....

Sheep:.....

Pigs:.....

Chicken:.....

Others:.....

Type of the main house owned by the household:

Grass thatched not plastered - 1

Grass thatched not plastered - 2

Iron roofed semi-permanent - 3

Iron roofed – permanent - 4

Iron roofed plastered - 5

What type of the household labour does the household use:

Exchange - 1

Hired - 2

Why does the household hire labour?

Specific activities (propagation) - 1

Specific crops-livestock - 2

Specific plots -3

General -4

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Education:

- 1 None
2 Primary
3 Junior
4 Secondary
5 Tertiary
- Work on farm: Yes-1
No-2
- Off Farm Emplm: Yes-1
No -2
- Member of orgn: Yes-1
No-2
- Leadership role: Yes-1
No -2

Plot Characteristics

Plot No.	1	2	3	4	5	6	7
Area of plot:							
Length							
Width							
Visible from house							
Slope/Niche							
Year acquired							
Distance from home							
Visited by extension in 5 years							
Distance to market from closest road							
Method of acquisition							

CODES:

Method of acquisition: Visibility from house: Visited by extension: Topography Location slope:

Bought -1 Yes -1 Yes -1 Hill top -1 Flat -1

Inherit -2 No -2 No -2 Midslope -2 Gentle -2

Given -3 Valley bottom-3 Steep -3

Rent -4 Very Steep-4

Plot characteristics

Plot No.	1	2	3	4	5	6	7
Current status of Plot							
Duration: Since when?							
If utilized, specify crops grown							
Use of field before acquisition.							
Seasons cultivated within last 5 years							
Soil status (classification)							
Stoniness							
Soil fertility							

CODES:

Status of plots:	Crops grown:	If fallowed, abandoned, why?
Seasonal fallow -1	Bean -1	Labour shortage - 1
Fallow - 2	Peas -2	In put shortage - 2
Abandoned -3	1.Potatoes-3	Plot is far -3
Neglected -4	S.Potatoes-4	Disputes -4
Others -5	Sorghum -5	Old age -5
Cropped -6	Woodcut -6	Poor health -6
	Others -7	Poor yields -7
		Others -8

Use of field:	Soil fertility:	Soil Status:	Stoniness:
Cultivated -1	Very fertile -1	Omucucu - 1	No stones -1
Not cultivated -2	Fertile -2	Enombe -2	Few stones -2
	Moderate -3	Eibumba -3	Moderate - 3
	Poor -4	Orushenyi -4	Stony -4
	Very poor -5	Endyoka -5	Rocky and Stony 5

Form of Management of Terraces:

Plot No.	1	2	3	4	5	6	7
Trees/Shrubs							
Species of top three Woody species							
Conservation measures							
Obstacles to management							

Trees/shrubs Code: Conservation measures: Species of top three

None - 1	Green manure -1
Very few -2	Organic manure-2
Moderate -3	Chemical In put-3
Dense -4	Others -4

Woody species:

Ekyiko -1
Ekyitoma -2
Eucalyptus -3

Obstacles to management:

Fires - 1
Theft - 2
Browsing 3
Distance - 4
Dispute - 5
Erosion - 6
Steep - 7
Age - 8
Extension - 9
Labour - 10
Animals - 11
Fertility - 12

Management factors and constraints

Plot No.	1	2	3	4	5	6	7
Distance between plots							
Age							
Animals							
Infertility							
Overcultivation							
Slope/steepness							
Size							
Extension worker							
Labour							
Plots not seen from home							

7: Anova Tables

Table 7.1: Analysis of Variance of Plot Distances to Home with Land Use Options

Source	Sum of Squares	df	Mean Square	F	Prob > F
Between groups	180.308	4	45.077	35.66	0.0000
Within groups	2997.344	2371	1.264		
Total	3177.652	2375	1.337		

Table 7.2: Analysis of Variance of Plot Distances to Roads with Land Use Options

Source	Sum of Squares	df	Mean Squares	F.Value	Prob > F
Between groups	57.019	4	14.254	6.04	0.0001
Within groups	5599.890	2371	2.361		
Total	5656.909	2375	2.381		

Table 7.3: Analysis of Variance of Farm Sizes and Land Use Options

Source	Sum of Squares	df	Mean Squares	F	Prob > F
Between groups	3526.095	4	881.523	10.64	(0.0000)
Within groups	196429.799	2371	82.846		
Total	199955.895	2375	84.191		

Table 7.4: Analysis of Variance of Polygamous Households with Land Use Options

Source	Sum of Squares	df	Mean Square	F	Prob > F
Between groups	2.092	4	0.523	6.13	0.0001
Within groups	202.411	2371	0.085		
Total	204.503	2375	.086		

Table 7.5: Analysis of Variance between plot markets and the land use options.

Source	Sum of Squares	df	Mean Square	F.Value	Prob > F
Between groups	384.264	4	96.066	4.95	0.0006
Within groups	45985.147	2371	19.394		
Total	46369.412	2375	19.523		

Table 7.6: Analysis of Variance between total number of plots and the land use options

Source	Sum of Squares	df	Mean Square	F	Prob > F
Between groups	766.126	4	191.531	12.87	0.0000
Within groups	35278.108	2371	14.878		
Total	36044.235	2375	15.176		

Table 7.7: Analysis of Variance between plot sizes and the land use options

Source	Sum of Squares	df	Mean Squares	F.Value	Prob > F
Between groups	7.734	4	1.933	1.46	0.2108
Within groups	3133.121	2371	1.321		
Total	3140.856	2375	1.322		

Table 7.8: Analysis of Variance between household sizes and the land use options

Source	Sum of Squares	df	Mean Square	F	Prob > F
Between groups	62.450	4	15.612	1.43	0.2206
Within groups	25841.770	2371	10.899		
Total	25904.220	2375	10.907		

Table 7.9: Analysis of Variance between age of household head and the land use options

Source	Sum of Squares	df	Mean Square	F	Prob > F
Between groups	1585.834	4	396.458	2.14	0.0733
Within groups	439012.387	2371	185.159		
Total	440598.222	2375	185.515		

Table 7.10: Analysis of Variance between Farmers' wealth and the land use options

Source	Sum of Squares	df	Mean Square	F.Value	Prob > F
Between groups	41.252	4	10.313	0.50	0.7359
Within groups	48917.467	2371	20.631		
Total	48958.720	2375	20.614		

8: Classification Table to Assess the Quality of the Model

Observed			Predicted			Percent correct
	Short fallow	Long fallow	Woodlot	Abandoned	Cropped	
Short fallow	0	15	2	10	178	0
Long fallow	2	74	19	51	203	21.2
Woodlot	0	19	69	24	93	33.7
Abandoned	1	46	27	64	119	24.9
Cropped	1	38	30	39	1406	92.9
Overall		7.6%	5.8%	7.4%	79%	63.3

9: Quality Assessment of the Model Using the Goodness of Fit

Model	-2log likelihood	Chi-square	Degrees of freedom	Significance
With constant term only	6135.902			
With all independent variables	5136.410	999.492	68	0.000